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A Computer Program for Analysis of Smoke Control Systems

U.S. DEPARTMENT OF COMMERCE
National Bureau of Standards
National Engineering Laboratory
Center for Fire Research
Washington, DC 20234

June 1982

Final Report

Sponsored in part by:

QC Department of Health and Human Services
100 Washington, DC 20201

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U.S. DEPARTMENT OF COMMERCE, Malcolm Baldrige, *Secretary*
NATIONAL BUREAU OF STANDARDS, Ernest Ambler, *Director*

PREFACE

This report is an interim product of a joint effort of the Department of Health and Human Services and the National Bureau of Standards (NBS), Center for Fire Research. The program is a multi-year activity initiated in 1975. It consists of projects in the areas of: decision analysis, fire and smoke detection, smoke movement and control, automatic extinguishment, and behavior of institutional populations in fire situations.

This report describes a computer program which analyzes pressurized stairwells and pressurized elevators. The program was initially intended as a research tool to investigate the feasibility of specific systems. However, this program may be of interest to design engineers responsible for pressurized stairwells or pressurized elevators.

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A COMPUTER PROGRAM FOR ANALYSIS OF SMOKE CONTROL SYSTEMS

John H. Klote

Abstract

This paper describes a computer program developed to analyze systems intended to control smoke in building fires. These systems include pressurized stairwells, pressurized elevator shafts, zone smoke control systems, and pressurized corridors. This program calculates air flows and differential pressures throughout a building in which a smoke control system is operating. The basic assumptions and limitations of the program are also discussed. The appendices contain a program listing and examples.

Key words: Air movement; computer programs; egress; elevator shafts; escape means; modeling; pressurization; simulation; smoke control; stairwells.

1. INTRODUCTION

The majority of fire fatalities result from smoke inhalation. As a result of this, a number of systems have been designed and built to control smoke movement in building fires. The most common smoke control systems are pressurized stairwells and zone smoke control systems¹. These systems are intended to control smoke movement in a building by use of air flows and by differential pressures. The computer program described in this paper provides a means to calculate the air flows and differential pressures throughout a building (either real or conceptual) in which a smoke control system is operating.

A number of computer programs have been developed which are applicable to smoke control. Some of these programs calculate steady state air flow and pressures throughout a building [1,2]². Other programs go beyond this to calculate smoke concentrations throughout a building that would be produced in the event of a fire [3-7]. In general, most of these programs are capable of analyzing smoke control

¹The concept of extending the use of smoke control to protect elevators is currently being investigated at NBS.

²Numbers in brackets refer to the literature references listed at the end of this paper.

systems. However, the program described in this paper has been specifically written for analysis of smoke control systems and is an extension of a program specifically written for analysis of pressurized stairwells and elevators [8]. While the basic theory of this program is the same as that of the stairwell program it has been extended to include analysis of (1) stairwells with vestibules, (2) elevators with elevator lobbies, (3) zone smoke control systems, and (4) pressurized corridors. The data input has been designed to minimize the quantity of required data and still maintain a high level of generality in the model. The output consists of the pressure differences across all of the building shafts, as well as the flows and pressures throughout the building.

This program was originally intended primarily as a research tool to investigate the feasibility of specific smoke control systems and to determine the interaction between these systems and the rest of the building. The predecessor [8] of this program has already been used to analyze pressurized stairwells without vestibules and to evaluate factors which affect the performance of these systems [9]. And, this program has been used to generate data for an National Bureau of Standards (NBS) Handbook on Smoke Control Design which is being developed. This paper is not intended to be a design guide for smoke control systems. The state-of-the-art of these systems is still under development and designers of these systems should seek the most current data available.

2. PROGRAM CONCEPT

In this computer program a building is represented by a network of spaces or nodes each at a specific pressure and temperature. The stairwells and other shafts are modeled by a vertical series of spaces, one for each floor. Air flows through leakage paths from regions of high pressure to regions of low pressure. These leakage paths are doors and windows which may be opened or closed. Leakage can also occur through partitions, floors, exterior walls and roofs. The air flow through a leakage path is a function of the pressure difference across the leakage path.

In this computer model air from outside the building can be introduced by a pressurization system into any level of a shaft or even into other building spaces. This allows simulation of stairwell pressurization, elevator shaft pressurization, stairwell vestibule pressurization, and pressurization of any other building space. In addition, any building space can be exhausted. This allows analysis of zone smoke control systems where the fire zone is exhausted and other zones are pressurized. The pressures throughout the building and flow rates through all the flow paths are obtained by solving the air flow network including the driving forces such as the wind, the pressurization system or an inside to outside temperature difference.

3. ASSUMPTIONS AND LIMITATIONS

1. Each space is considered to be at one specific pressure and one specific temperature.
2. The flows and leakage paths are assumed to occur at mid-height of each level.
3. The net air supplied by the air handling system or by the pressurization system is assumed to be constant and independent of building pressure.
4. The outside air temperature is assumed to be constant.
5. The barometer pressure at ground level is assumed to be standard atmospheric pressure ($101325 P_a$)³.

4. EQUATIONS

A. Flow equation

$$F = CA \sqrt{2\rho\Delta P} \quad (3.1)$$

where:

F = mass flow rate

C = flow coefficient

A = flow area

ρ = density of air in flow path

ΔP = pressure difference across flow path

The flow coefficient is dimensionless and for smoke control analysis it is generally taken to be in the range of 0.6 to 0.7. Because of the large number of flow calculations performed during the computer analysis the flow equation is rewritten in the program as $F = C' \sqrt{\Delta P}$. Using the ideal gas law, the adjusted flow coefficient, C' , can be expressed as

$$C' = CA \sqrt{\frac{2 P_{atm}}{RT}} \quad (3.2)$$

where:

P_{atm} = absolute barometric pressure at ground level

R = gas constant of air

T = absolute temperature of air in flow path

³The results of the program are not very sensitive to changes in atmospheric pressure. For altitudes considerably different from sea level the more accurate value can be substituted by changing an assign statement in the subroutine INPUT and one in the subroutine CORR.

B. Mass Balance Equations

For building compartment⁴ i

$$\sum_{j=1}^{N_c} F_{(i,j)} + \sum_{k=1}^{N_o} F_{o(i,k)} + F_{f(i)} = 0 \quad (3.3)$$

and for shafts

$$\sum_{i=N_1}^{N_2} \left[\sum_{j=1}^{N_c} F_{(i,j)} + \sum_{k=1}^{N_o} F_{o(i,k)} + F_{f(i)} \right] = 0 \quad (3.4)$$

where:

$F_{(i,j)}$ = mass flow rate from space j to space i. For building compartments this flow can be either horizontal or vertical, however for shafts this flow can only be horizontal.

$F_{o(i,k)}$ = mass flow rate from direction k outside of the building to space i.

$F_{f(i)}$ = net mass flow rate of air due to the air handling system or due to a pressurization system.

N_c = number of building spaces connected to space i.

N_o = number of connections to the outside from space i.

N_1 is the space number at the bottom level of the shaft and the spaces in the shaft are numbered consecutively up to N_2 which is the space number at the top of the shaft.

C. Shaft Pressures

The following relationship is used to calculate the gage pressure, $P_{(i)}$, at floor i of a shaft in terms of $P_{(i-1)}$ at floor i - 1.

$$P_{(i)} = P_{(i-1)} - P_z - P_f \quad (3.5)$$

where:

P_z = hydrostatic pressure difference

P_f = pressure loss due to friction

The following equation is used to calculate the hydrostatic pressure difference.

⁴In this paper the term building compartment refers to a space in a building other than in a shaft.

$$P_z = \frac{g\bar{P}}{RT} h_{(i)} - h_{(i-1)} \quad (3.6)$$

where:

$h_{(i)}$ = height of point i

$h_{(i-1)}$ = height of point i-1

g = gravitational acceleration

R = gas constant

$$\bar{T} = \frac{T_{(i)} + T_{(i-1)}}{2}$$

$$\bar{P} = \frac{P_{(i)} + P_{(i-1)}}{2} + P_b$$

P_b is a constant used to convert an average gage pressure to the average absolute pressure, $\bar{P}$.

The following equation is used to calculate the pressure loss due to friction.

$$P_f = S \left(\frac{\dot{m}_u}{C_s} \right)^2 \quad (3.7)$$

where:

$\dot{m}_u$ = upward flow from i-1 to i in shaft

C_s = shaft flow coefficient

S = sign of $\dot{m}_u$

D. Outside Pressures

Outside pressures can either be entered by the user or can be calculated by the following method.

$$P_{O(i)} = P_{h(i)} + C_w P_{v(i)} \quad (3.8)$$

where:

$P_{O(i)}$ = outside gage pressure at height $h(i)$ above absolute pressure at ground level

$P_{h(i)}$ = hydrostatic pressure difference between $h(i)$ and ground level

$P_{v(i)}$ = velocity pressure due to the wind at height $h(i)$

C_w = pressure coefficient

Because the outside temperature is constant

$$P_{h(i)} = P_{atm} \exp \left(- \frac{gh(i)}{RT_{out}} \right) - P_b \quad (3.9)$$

where:

P_{atm} = absolute barometric pressure at ground level

T_{out} = outside absolute temperature

When the outside pressures are calculated by the computer the wind velocities are assumed to be described by the power law.

$$v = v_o \left(\frac{h}{h_o} \right)^n$$

where:

v_o = wind velocity at height h_o

n = wind exponent

This relationship has been extensively used to describe the boundary-layer velocity profile of the wind near the surface of the earth. It assumes that the terrain surrounding the building is homogeneous. That is, that there are no large obstructions near the building which could produce local wind effects. A value of 0.16 for the wind exponent is appropriate for flat terrain. The wind exponent increases with rougher terrain. For very rough terrain such as urban areas a value of 0.40 would be appropriate.

The equation for the velocity pressure at height $h(i)$ is obtained by substituting the velocity from the power law into the usual relation for velocity pressure ($P_v = \frac{1}{2} \rho v^2$).

$$P_v = \frac{\rho v_o^2}{2} \left(\frac{h(i)}{h_o} \right)^{2n} \quad (3.10)$$

where ρ is the outside air density.

The pressure coefficients are in the range of -0.8 to 0.8 where positive values are for windward walls and negative values are for leeward walls. The z pressure coefficient depends upon building geometry and varies locally over the wall surface. Numerical values for C_w and n as well as practical engineering information are available from a number of sources [10-13].

5. PROGRAM DESCRIPTION

This program is written in ANSI FORTRAN on the UNIVAC 1100/82 and a program listing is provided in appendix D. The following is a detailed description of the main program and the major subroutines.

5.1 Main Program

The main program calls the subroutines which read the data, calculate the adjusted flow coefficients, calculates the initial values of pressures and iteratively solves for the pressures according to the logic illustrated in the flow chart of figure 1.

5.2 INPUT Subroutine

This routine reads the data that are necessary for a flow analysis of the stairwell or elevator, including an analysis of the rest of the building. These data consist of the following:

1. Outside temperature.
2. Temperature throughout the building.
3. Outside pressures. These can be entered or calculated as described earlier.
4. Description of the flow network including flow coefficients and flow areas for all connections and the net air flows to each space due to the air conditioning system or due to a pressurization system.

The data above can be entered in either SI units or in engineering units. Appendix A contains a detailed description of the data input method.

In addition to reading data, this subroutine provides temperature and pressure data as well as a complete description of the flow network. This routine also calculates initial estimates of the hydrostatic pressure differences. When data is entered in engineering units the subroutine UNITS is called which converts all units to the SI system.

5.3 CORR Subroutine

This routine calculates adjusted flow coefficients for all flow paths using eq. (3.2). Two sets of these coefficients are calculated for each flow path to allow for flow in either direction.

5.4 INIT Subroutine

This routine calculates initial estimates of the building pressures by a technique used by Sander [1]. In this technique, mass flows are considered linear functions of differential pressure and therefore the flow equations can be expressed and solved in matrix form. In this estimate, shaft pressures are considered hydrostatic. The resulting pressures form a starting point for the iterative solution which follows.

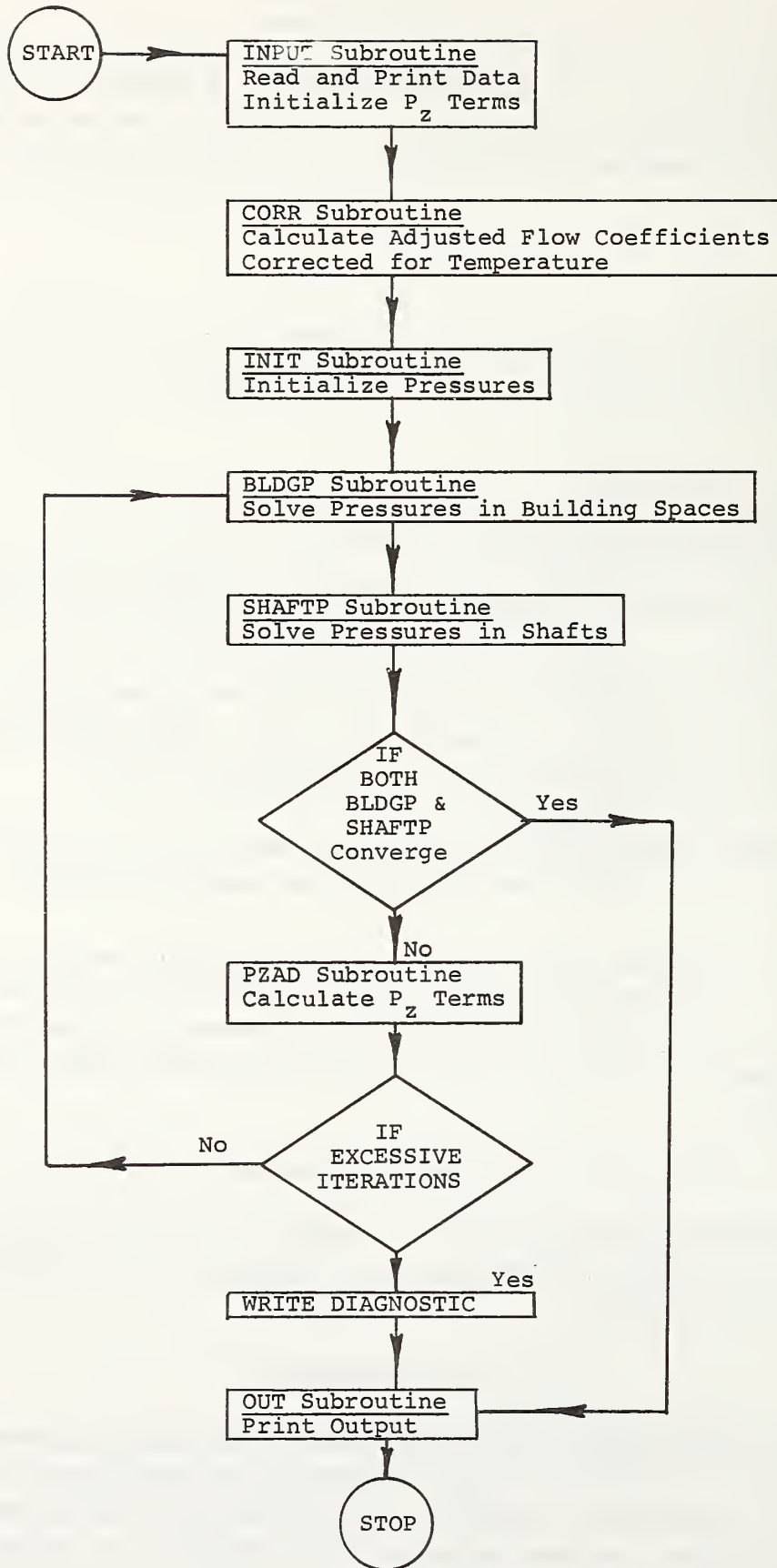


Figure 1. Flow chart for main program

5.5 BLDGP Subroutine

The iterative solution for the building pressures and flows consists of the three subroutines BLDGP, SHAFTP and PZAD. The subroutine BLDGP operates on the building compartments sequentially. The sum of all the mass flows into compartment i is calculated. If the absolute value of this sum is less than a convergence limit then eq. (3.3) is considered satisfied and the computer proceeds to the next compartment or returns to the main program. However, if the absolute value of the sum is greater than the convergence limit, then an improved estimate of the pressure at compartment i is obtained by the regula falsi method [14]. When none of the pressures need to be modified this routine passes a convergence signal to the main program.

5.6 SHAFTP Subroutine

The structure of this routine is very similar to that of BLDGP except that it operates on shafts sequentially. The sum of all the mass flows into shaft i is calculated. If the absolute value of this sum is less than the convergence limit then eq. (3.4) is also considered satisfied and the computer proceeds to the next shaft or returns to the main program. However, if the absolute value of the sum is greater than the convergence limit, then improved estimates of the shaft pressure are calculated. This is done by changing the pressures at the bottom of the shaft and then recalculating the shaft pressure by eq. (3.5). Again the regula falsi method is used, and if none of the shaft pressures require modification a convergence signal is passed to the main program. It can be seen from figure 1 that if convergence is achieved in both BLDGP and SHAFTP, then the subroutine OUT will print the solution. Otherwise, the hydrostatic pressure differences are adjusted in the subroutine PZAD.

5.7 PZAD Subroutine

This routine calculates hydrostatic pressure differences by eq. (3.6) using the most recent pressure estimates.

5.8 OUT Subroutine

This routine outputs mass flows and pressures for the flow network as well as the differential pressures across each shaft. If the data input was in engineering units then appropriate variables are converted to the engineering system before output.

6. FUTURE DIRECTION

It is planned to use this computer program in a project at NBS to study the feasibility of protected elevators as a means of fire escape for handicapped individuals. Consideration is being given to further development of the program for use as a design tool. Also, a program may be developed for microcomputers which can be used interactively.

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APPENDIX A. DATA INPUT DESCRIPTION FOR
COMPUTER PROGRAM

Data input consists of the following elements:

1. Initial data
2. Building heights
3. Temperature profiles
4. Outside pressure profiles
5. Building data
6. Shaft data

Each of these input elements is described in detail in the following sections. Elements 1 through 6 are always required. In the following sections the input required for each of the six data elements is described in detail. Each block or group of blocks below represent an input card. Unless otherwise stated these cards are unformatted; that is, the numbers do not have to be placed in specific columns and integers can be written with or without decimal points. However, separate pieces of numerical data must be separated by one or more spaces. Examples of input data are provided in Appendix B.

1. Initial data

project title (col. 1-72)

outside
temperature (°C, °F)

unit indication
(1 for SI, 2 for Eng)

summary output
(0 for none, or file number)¹

¹The user must assign this file before program execution.

2. Building heights

N_h , no. of building
levels

input parameter
(either 0 or 1)

If input parameter = 0, then heights for each building level are to be individually entered as follows:

$h_{(1)}$	$h_{(2)}$	$h_{(3)}$		$h_{(i)}$		$h_{(N_h)}$
			...		...	

where $h_{(i)}$ is the height of the center of level i above the ground (m, ft).

If input parameter = 1, then the following card must be entered.

$h_{(1)}$	distance between floors (m, ft)
-----------	------------------------------------

3. Temperature profiles

no. of temperature profiles

For each temperature profile the following data must be supplied.

no. of temp. points	level no.	temperature (°C, °F)	level no.	temperature (°C, °F)	level no.	temperature (°C, °F)
------------------------	--------------	-------------------------	--------------	-------------------------	--------------	-------------------------

4. Outside pressure profiles

N_{po}	
no. of outside	input parameter
pressure profiles	(either 0 or 1)

--	--

If the input parameter = 0, each outside pressure profile is entered as follows:

$$P_{O(1)} \quad P_{O(2)} \quad P_{O(3)} \quad P_{O(i)} \quad P_{O(N_h)}$$

$$\square \quad \square \quad \square \quad \cdots \quad \square \quad \cdots \quad \square$$

where $P_{o(i)}$ is the outside pressure at the center of level i .

If the input parameter = 1, the outside pressures are calculated and the following data are required.

V_o
wind velocity
(mph)

h_o
height at which
velocity is measured

n
wind
exponent

□

pressure coefficients for each pressure profile

$$C_{W(1)} \quad C_{W(2)} \quad C_{W(N_{po})}$$

☐ ☐ ... ☐

5. Building data

$$N_f$$

no. of levels
(or floors)

All of the following data in this input element are supplied for each level, or consecutive groups of similar levels.

I_1	I_2	N_{com}
Starting floor	Ending floor	No. of compartments per floor

--	--	--

(Floor data is entered in ascending order of levels or floors. When data is for only one level then $I_1 = I_2$, and the same number is supplied for both.)

For each compartment on a level the following data are supplied:

N_{CS}	N_{CA}	N_{CO}	F_f	
No. of connections to other compartments on the same level	No. of connections to compartments on the level above	No. of connections to the outside	Net flow ² (l/s, cfm)	Temperature profile number

--	--	--	--	--

For each connection between this compartment and another on the same floor the following data are required.

Other compartment number on the same level	C flow coefficient	A flow area (m ² , ft ²)
--	-------------------------	---

--	--	--

For each connection between this compartment and one on the level above the following data are required.

²All net flows are at standard conditions of 21°C (70°F) and one atmosphere.

Other compartment
number on floor
above

C
flow coefficient

A
flow area
(m², ft²)

For each connection to the outside the following data are required.

outside pressure
profile number

C
flow coefficient

A
flow area
(m², ft²)

6. Shaft data

no. of shafts

All of the following data in this input element are required for each shaft.

shaft title (col 1-20)

C_s
shaft flow
coefficient

bottom
level of shaft

top level
of shaft

temperature
profile number

Enter the following typical data which applies to each level of the shaft.

Exceptions can be entered later.

no. of connections
between typical
level of shaft and
outside

F_f
net flow into
typical level
of shaft
(l/s, cfm)

The connection data to the building for a typical level are required.

compartment no.
to which shaft is
connected

C
flow coefficient

A
flow area
(m², ft²)

For each connection to the outside, the connection data for a typical floor are required.

outside pressure
profile

C
flow coefficient

A
flow area
(m², ft²)

The number of exceptions to the typical data is required.

no. of exceptions

All of the following data in this input element are required for each exception.

exception type
(1, 2 or 3)

level of shaft

The next card depends on the exception type. For exception type = 1, to the net flow into the floor of the shaft is defined.

F_f
net flow
(l/s, cfm)

For exception type = 2, an exception to an outside connection for this shaft is defined.

outside pressure
profile number

C
flow coefficient

A
flow area
(m², ft²)

For exception type = 3, an exception to the connection between the shaft and the building is defined.

compartment no.
to which shaft
is connected

C
flow coefficient

A
flow area
(m², ft²)

APPENDIX B. INPUT EXAMPLES

1. Example 1

A ten story building with a pressurized stairwell and no vertical leakage within the building is heated to 70°F when the outside temperature is -20°F. The stairwell temperature is 60°F at the tenth floor and 50°F at the bottom floor. The stairwell is pressurized by a net 550 cfm¹ per floor. The wind is 30 mph at a height of 30 ft and the wind exponent is 0.14. This building has connections to the outside in two directions. The wind pressure coefficients are 0.7 for the windward wall and -0.7 for the leeward wall. The flow areas are the same vertically and are listed in Table B1. The flow coefficient is taken to be 0.65 for all connections.

Table B1. Flow areas for example 1

Connection location	Area (ft ²)
Between stairwell & building	0.42
Between building & outside into the wind	0.75
Between building & outside away from the wind	0.75

1.1 Data for Computer Input

<i>initial data</i>	{	TEN STORY BUILDING WITHOUT VERTICAL LEAKAGE			
		-20	20		
<i>building heights</i>	{	10	1		
		5	10		
<i>temperature profiles</i>	{	2			
		1	1	70	
		2	1	50	10 60
<i>outside pressure profiles</i>	{	2	1		
		30	30	.15	
		0.7	-0.7		

¹At standard conditions of 21°C (70°F) and one atmosphere.

<i>building data</i>	{	10				
		1	10	1		
		0	0	2	0	1
		1	.65	0.75		
		2	.65	0.75		

<i>shaft data</i>	{	1			
		STAIRWELL			
		80000	1	10	2
		0	550		
		1	.65	.42	
		0			

2. Example 2

This is a 10 story building which is 70°F inside. Outside the air temperature is -5°F and there is no wind. This building has a stairwell and an elevator. The flow areas which are generally the same vertically are listed in table B2 and the flow exponents are taken to be 0.5. The stairwell is pressurized by a net 550 cfm per floor. The elevator shaft has a 4 ft² vent to the outside at the top. On floors 2 through 10 the elevator lobby separated from the building by doors that automatically close in the event of a fire. The flow coefficient is taken as 0.65 in all connections.

Table B2. Flow areas for example 2

Connection location	Area (ft ²)
Between stairwell & building	0.42
Between building & outside	1.5
Between elevator & elevator lobby	0.65
Between elevator lobby & building	0.55

2.1 Data for Computer Input

<i>initial data</i>	{	TEN STORY BUILDING WITH ELEVATOR
	{	-5 2 0

<i>building heights</i>	{	10 1
	{	5 10

<i>temperature profile</i>	{	1
	{	1 1 70

<i>outside pressure data</i>	{	1 1
	{	0 1 1
	{	1

building
data { 10

1st
floor { 1 1 1 0 1
0 0 1
1 0.65 0.75

2nd
through
10th floors { 2 10 2 0 1
1 0 1
2 0.65 0.55
1 0.65 0.75
0 0 0 0 1

shaft
data { 2

shaft 1 { STAIRWELL
80000 1 10 1
0 550
1 .65 .42
0

shaft 2 { ELEVATOR
2.7E6 1 10 1
0 0
2 .65 .65
2
2 10
1 .65 4.0
3 1
1 .65 .65

2.2 Example 2 Output

The output for example 2 case 1 (the data above not including modifications for Cases 2 and 3) is given in appendix C.

APPENDIX C. EXAMPLE OUTPUT

EXAMPLE OUTPUT

DATE 100281

TEN STORY BUILDING WITH ELEVATOR

OUTSIDE TEMPERATURE -5.0 F

HEIGHT FT	TEMPERATURE PROFILES (DEG F)
	1
5.00	70.0
15.00	70.0
25.00	70.0
35.00	70.0
45.00	70.0
55.00	70.0
65.00	70.0
75.00	70.0
85.00	70.0
95.00	70.0

HEIGHT FT	OUTSIDE PRESSURE PROFILES (IN H2O)
	1

5.00	1.909
15.00	1.741
25.00	1.574
35.00	1.406
45.00	1.239
55.00	1.071
65.00	.904
75.00	.736
85.00	.569
95.00	.402
24	ITERATIONS

THE FOLLOWING UNITS ARE USED FOR OUTPUT

FLOW IN CFM AT 70 DEG F AND 1 ATM
PRESSURE IN INCHS H2O
AREA IN FEET SQUARED

DATE 100281

EXAMPLE OUTPUT
TEN STORY BUILDING WITH ELEVATOR

FLOOR	COMPARTMENT	TEMP PRESSURE	TEMP PROFILE	FIXED FLOW	CONNECTION	TO	DIFFERENTIAL PRESSURE	ADJUSTED FLOW COEFFICIENT	FLOW AREA	FLOW
1	1	1.903	1	0.	STAIRWELL ELEVATOR	OUTSIDE DIRECTION 1	.182 -.136 .006	1095. 1694. 2110.	.039 .650 .750	467.5 -624.7 157.2 -.1 NET
2	1	1.744	1	0.	FLOOR 2 COMPARTMENT STAIRWELL	OUTSIDE DIRECTION 1	-.070 .197 -.003	1434. 1095. 1955.	.051 .420 .750	-380.3 486.3 -106.4 -.4 NET
2	2	1.674	1	0.	FLOOR 2 COMPARTMENT ELEVATOR		.070 -.050	1434. 1694.	.051 .650	380.3 -380.5 -.1 NET
3	1	1.581	1	0.	FLOOR 3 COMPARTMENT STAIRWELL	OUTSIDE DIRECTION 1	-.059 .217 -.007	1434. 1095. 1955.	.051 .420 .750	-348.0 509.9 -162.2 -.3 NET
3	2	1.522	1	0.	FLOOR 3 COMPARTMENT ELEVATOR		.059 -.042	1434. 1694.	.051 .650	348.0 -348.0 .0 NET
4	1	1.418	1	0.	FLOOR 4 COMPARTMENT STAIRWELL	OUTSIDE DIRECTION 1	-.048 .235 -.012	1434. 1095. 1955.	.051 .420 .750	-314.9 530.8 -216.2 -.3 NET
4	2	1.370	1	0.	FLOOR 4 COMPARTMENT ELEVATOR		.048 -.035	1434. 1694.	.051 .650	314.9 -315.0 -.1 NET
5	1	1.257	1	0.	FLOOR 5 COMPARTMENT STAIRWELL	OUTSIDE DIRECTION 1	-.038 .252 -.019	1434. 1095. 1955.	.051 .420 .750	-260.9 549.5 -268.8 -.3 NET
5	2	1.219	1	0.	FLOOR 5 COMPARTMENT ELEVATOR		.038 -.028	1434. 1694.	.051 .650	260.9 -281.1 -.2 NET
6	1	1.098	1	0.	FLOOR 6 COMPARTMENT STAIRWELL	OUTSIDE DIRECTION 1	-.029 .267 -.027	1434. 1095. 1955.	.051 .420 .750	-245.4 566.1 -320.7 -.0 NET
6	2	1.069	1	0.	FLOOR 6 COMPARTMENT ELEVATOR		.029 -.021	1434. 1694.	.051 .650	245.4 -245.7 -.3

DATE 100281

EXAMPLE OUTPUT

TEN STORY BUILDING WITH ELEVATOR

FLOOR	COMPARTMENT	PRESSURE	TEMP PROFILE	FIXED FLOW	CONNECTION	TO	DIFFERENTIAL PRESSURE	ADJUSTED FLOW COEFFICIENT	FLOW AREA	FLOW
7	1	.940	1	0.	FLOOR 7 COMPARTMENT STAIRWELL OUTSIDE DIRECTION	2	-.021 .281 -.036	1434. 1095. 1955.	.051 .420 .750	-208.2 580.7 -372.7 -.2 NET
7	2	.919	1	0.	FLOOR 7 COMPARTMENT ELEVATOR	1	.021 -.015	1434. 1694.	.051 .650	208.2 -208.4 -.2 NET
8	1	.784	1	0.	FLOOR 8 COMPARTMENT STAIRWELL OUTSIDE DIRECTION	2	-.014 .294 -.047	1434. 1095. 1955.	.051 .420 .750	-168.3 593.4 -425.3 -.2 NET
8	2	.770	1	0.	FLOOR 8 COMPARTMENT ELEVATOR	1	.014 -.010	1434. 1694.	.051 .650	168.3 -168.4 -.2 NET
9	1	.629	1	0.	FLOOR 9 COMPARTMENT STAIRWELL OUTSIDE DIRECTION	2	-.008 .304 -.060	1434. 1095. 1955.	.051 .420 .750	-124.6 604.0 -479.6 -.2 NET
9	2	.622	1	0.	FLOOR 9 COMPARTMENT ELEVATOR	1	.008 -.005	1434. 1694.	.051 .650	124.6 -124.8 -.2 NET
10	1	.477	1	0.	FLOOR 10 COMPARTMENT STAIRWELL OUTSIDE DIRECTION	2	-.003 .313 -.075	1434. 1095. 1955.	.051 .420 .750	-75.3 612.0 -537.0 -.4 NET
10	2	.475	1	0.	FLOOR 10 COMPARTMENT ELEVATOR	1	.003 -.002	1434. 1694.	.051 .650	75.3 -75.5 -.2 NET

EXAMPLE OUTPUT

DATE 100281

STAIRWELL

TEMPERATURE PROFILE 1
SHAFT FLOW COEFFICIENT 80000.

FLOOR	PRESSURE	FIXED FLOW	CONNECTION	TO	DIFFERENTIAL PRESSURE	ADJUSTED FLOW COEFFICIENT	FLOW AREA	FLOW
1	2.086	550.	FLOOR 1	COMPARTMENT 1	-.182	1095.	.039	-467.5
2	1.942	550.	FLOOR 2	COMPARTMENT 1	-.197	1095.	.039	-486.3
3	1.798	550.	FLOOR 3	COMPARTMENT 1	-.217	1095.	.039	-509.9
4	1.653	550.	FLOOR 4	COMPARTMENT 1	-.235	1095.	.039	-530.8
5	1.509	550.	FLOOR 5	COMPARTMENT 1	-.252	1095.	.039	-549.5
6	1.365	550.	FLOOR 6	COMPARTMENT 1	-.267	1095.	.039	-566.1
7	1.221	550.	FLOOR 7	COMPARTMENT 1	-.281	1095.	.039	-580.7
8	1.078	550.	FLOOR 8	COMPARTMENT 1	-.294	1095.	.039	-593.4
9	.934	550.	FLOOR 9	COMPARTMENT 1	-.304	1095.	.039	-604.0
10	.790	550.	FLOOR 10	COMPARTMENT 1	-.313	1095.	.039	-612.0
								-.1 NET

ELEVATOR

TEMPERATURE PROFILE 1
SHAFT FLOW COEFFICIENT 2700000.

FLOOR	PRESSURE	FIXED FLOW	CONNECTION	TO	DIFFERENTIAL PRESSURE	ADJUSTED FLOW COEFFICIENT	FLOW AREA	FLOW
1	1.767	0.	FLOOR 1	COMPARTMENT 1	.136	1694.	.060	624.7
2	1.623	0.	FLOOR 2	COMPARTMENT 2	.050	1694.	.060	380.5
3	1.479	0.	FLOOR 3	COMPARTMENT 2	.042	1694.	.060	348.0
4	1.335	0.	FLOOR 4	COMPARTMENT 2	.035	1694.	.060	315.0
5	1.191	0.	FLOOR 5	COMPARTMENT 2	.028	1694.	.060	281.1
6	1.048	0.	FLOOR 6	COMPARTMENT 2	.021	1694.	.060	245.7
7	.904	0.	FLOOR 7	COMPARTMENT 2	.015	1694.	.060	208.4
8	.760	0.	FLOOR 8	COMPARTMENT 2	.010	1694.	.060	168.4
9	.616	0.	FLOOR 9	COMPARTMENT 2	.005	1694.	.060	124.2
10	.473	0.	FLOOR 10	COMPARTMENT 2	.002	1694.	.060	75.5
								-2772.5
								-.4 NET
								10426.

APPENDIX D. PROGRAM LISTING

MAIN PROGRAM

@NBS*PLIB\$.SHOW A.MAIN

```

C
C   COMPLTER PROGRAM FOR AIR FLOW ANALYSIS IN BUILDINGS
C   SPECIFICALLY FOR ANALYSIS OF SMOKE CONTROL SYSTEMS
C
C   PROGRAM VARIABLES
C   AI      LEAKAGE AREA OF INTERNAL CONNECTION
C   AO      LEAKAGE AREA OF CONNECTION TO OUTSIDE
C   C       FLOW COEFFICIENT BETWEEN BUILDING POINTS
C   CO      FLOW COEFFICIENT TO OUTSIDE
C   CS      FLOW COEFFICIENT OF SHAFT
C   E       LIMIT WITHIN WHICH CONVERGENCE IS ACCEPTABLE
C   F       NET FLOW INTO POINT I
C   FC      FLOW BETWEEN INTERNAL POINTS
C   FF      FIXED FLOW INTO POINT I
C   FO      FLOW TO OUTSIDE
C   FSS     NET FLOW INTO SHAFT IS
C   F       HEIGHT FROM GROUND TO MIDPOINT OF FLOOR
C   IBUG    OUTPUT VARIABLE
C   ICONV   INTEGER USED IN SUBROUTINES BLDGP AND SHAFTP
C           IF ICONV = 0 THEN THE PRESSURES WERE UNCHANGED
C   IFLOOR  FLOOR LEVEL WHERE POINT IS LOCATED
C   IT      POINTER TO TEMP PROFILE FOR POINT I
C   ITS     POINTER TO TEMPERATURE PROFILE OF SHAFT
C   JC      POINT NO. CONNECTED TO POINT I
C   JOC     DIRECTION OF OUTSIDE CONNECTION
C   N       NO. OF BUILDING COMPARTMENTS
C   NC      NO. OF INTERNAL POINTS CONNECTED TO POINT I
C   NCO     NO. OF OUTSIDE CONNECTIONS
C   NFS1    BOTTOM FLOOR OF SHAFT
C   NFS2    TOP FLOOR OF SHAFT
C   NH      NO. OF FLOORS
C   NPC     NO. OF OUTSIDE PRESSURE PROFILES
C   NS      NO. OF SHAFTS
C   NS1     I VALUE FOR START OF SHAFT
C   NS2     I VALUE FOR END OF SHAFT
C   NT      TOTAL NO. OF POINTS (BLDG AND SHAFT)
C   NTP     NO. OF TEMPERATURE PROFILES
C   P       PRESSURE AT POINT I
C   PFO     OUTSIDE PRESSURE PROFILES
C   PO      OUTSIDE PRESSURE
C   PS      PRESSURE PROFILE OF SHAFT - WORKSPACE
C   PZ      PRESSURE DUE TO ELEVATION DIFFERENCE
C   T       TEMPERATURE PROFILE ARRAY
C   TITLE   PROJECT TITLE
C   TITSH   SHAFT TITLE
C
C   PROGRAM PARAMETERS
C   MB      MAX NO. OF BUILDING COMPARTMENTS
C   MM      MAX NO. OF POINTS
C   MS      MAX NO. OF SHAFTS
C   MC      MAX NO. OF CONNECTIONS FOR ANY POINT
C   MPO     MAX NO. OF OUTSIDE PRESSURE PROFILES
C   MTP     MAX NO. OF TEMPERATURE PROFILES
C   MFL     MAX NO. OF FLOORS

```

MAIN PROGRAM

```

C
C
PARAMETER (MM=140,MS=8,MC=9,MFC=2,MTP=2,MFL=25,MB=50)
COMMON NT, P(MM),C(MM,MC),NC(MM),JC(MM,MC),ITS(MS),
1 FC(MM,MC),PZ(MM,MC),PO(MM,MPO),CO(MM,MPO),F(MM),PFU(MFL,MPO),
2 FF(MM),FO(MM,MPO),CS(MS),PS(MFL),NS1(MS),NS2(MS),
3 FSS(MS),N,NS,NPO,ICONV,E,IBUG,AI(MM,MC),AO(MM,MPO),TITSH(MS,5),
4 NF,F(MFL),IFLOOR(MM),T(MTP,MFL),NFS1(MS),NFS2(MS),IT(MB),NTP
5 ,NCC(MM),JOC(MM,MPO),TOUT
DOUBLE PRECISION P,PO,PS
COMMON /RUN/IRUN
DIMENSION B1(MM,MC),B2(MM,MPO)
NITER=5000
IRUN=1

C
C CALL INPUT TO READ DATA
C
CALL INPUT
C
E=0.2
20 ICS=1
C
C SAVE AI(I,J) IN B1(I,J) AND FIND
C MAX VALUE OF AI(I,J)
C
AZZ=C
AMAX=0
DO 10 I=1,NT
DO 8 J=1,MC
B1(I,J)=AI(I,J)
IF(AI(I,J) .GT. AMAX)AMAX=AI(I,J)
E CONTINUE
DO 9 J=1,MPO
E2(I,J)=AO(I,J)
IF(AO(I,J) .GT. AMAX)AMAX=AO(I,J)
9 CONTINUE
10 CONTINUE
C
C ADJUST FOR LARGE VALUES OF FLOW AREA
C
IF(AMAX .LT. 0.3)GO TO 25
AZZ=1
AM=0.2/(AMAX-0.1)
BB=0.1*(1.0-AM)
DO 15 I=1,NT
DO 12 J=1,MC
IF(AI(I,J) .LT. 0.1)GO TO 12
AI(I,J)=AM*AI(I,J)+BB
12 CONTINUE
DO 14 J=1,MPO
IF(AO(I,J) .LT. 0.1)GO TO 14
AO(I,J)=AM*AO(I,J)+BB
14 CONTINUE
15 CONTINUE
C
C TEMPERATURE CORRECTION
C
25 CALL CCRR

```

MAIN PROGRAM

```

C
C      CALL INIT TO INITIALIZE PRESSURE ARRAY , P
C
22  CALL INIT
C
C      DO LCOP TO 30 IS ITERATIVE SOLUTION TO PRESSURE ARRAY
C
24  DO 30 ITER=1,NITER
C
C      CALL BLDGP TO SOLVE FOR BUILDING PRESSURES
C
CALL BLDGP
ICE=ICUNV
IF(ICB .EQ. 0 .AND. ICS .EQ. 0)GO TO 40
C
C      CALL SHAFTP TO SOLVE FOR SHAFT PRESSURES
C
CALL SHAFTP
ICS=ICUNV
IF(ICB .EQ. 0 .AND. ICS .EQ. 0)GO TO 40
C
C      CALL PZAD TO CALCULATE PZ TERMS
C
CALL PZAD
30  CONTINUE
C
C      IF ROUTINE FAILS TO CONVERGE IN NITER
C      ITERATIONS PRINT ERROR MESSAGE
C
WRITE(6,800)
40  CONTINUE
WRITE(6,801)ITER
IF(AZZ .EQ. 0.)GO TO 42
AZZ = 0.
DO 60 I=1,NT
DO 50 J=1,MC
50  AI(I,J)=B1(I,J)
DO 55 J=1,MPO
55  AO(I,J)=B2(I,J)
60  CONTINUE
CALL CCRR
GO TO 24
C
C
C
C      CALL OUT TO OUTPUT SOLUTION
C
42  CALL OUT
C
WRITE(6,805)
STOP
C
C
C      FORMAT STATEMENTS
C
800  FORMAT(/////5X,35(1H1)//5X,
+35HFAILURE OF MAIN PROGRAM TO CONVERGE //5X,35(1H1)//)

```

MAIN PROGRAM

```
E01  FORMAT( 10X,I5,5X,11HITERATIONS  )
E05  FORMAT(1F1)
      END
```

@HDG,P

SUBROUTINE INPUT.L,1

SUBROUTINE INPUT

&NBS*PLIB\$.SHOW A.INPUT

SUBROUTINE INPUT

```

C
C   THIS ROUTINE READS AND PRINTS DATA
C   AND INITIALIZES PZ ARRAY
C
PARAMETER (MM=140,MS=8,MC=9,MPO=2,MTP=2,MFL=25,MB=50)
COMMON /PZZ/ PGZ
COMMON /IO/TITLE(18),IOUT,IUNIT,NCOMP(MFL),SNCOMP(MFL)
COMMON NT, P(MM),C(MM,MC),NC(MM),JC(MM,MC),ITS(MS),
1 FC(MM,MC),PZ(MM,MC),PG(MM,MPC),CO(MM,MPO),F(MM),PFO(MFL,MPO),
2 FF(MM),FO(MM,MPO),CS(MS),PS(MFL),NS1(MS),NS2(MS),
3 FSS(MS),N,NS,NPO,ICONV,E,IBUG,AI(MM,MC),AO(MM,MPO),TITSH(MS,5),
4 NH,F(MFL),IFLOOR(MM),T(MTP,MFL),NFS1(MS),NFS2(MS),IT(MB),NTP
5 ,NCC(MM),JOC(MM,MPO),TOLT
DOUBLE PRECISION P,PO,PS
CHARACTER PAR*6
DIMENSION II(MFL),TT(MFL),PAR(7),CW(MPO),PH(MFL),NZZ(MM)
DATA PAR/' MM',' MS',' MC',' MPO',' MTP',' MFL',' MB'/
IBUG=0

C
C   READ AND WRITE PROJECT TITLE
C
READ(5,600)(TITLE(I),I=1,18)
WRITE(6,601)(TITLE(I),I=1,18)

C
C   READ GENERAL DATA
C
C   TOLT = OUTSIDE TEMPERATURE
C   IUNIT = 1 FOR SI UNITS
C           = 2 FOR ENG UNITS
C   ICLT = 0 FOR NO SUMMARY OUTPUT
C   OTHERWISE IOUT IS FILE NO. TO
C   WHICH SUMMARY OUTPUT IS WRITTEN
C
READ(5,700)TOUT,IUNIT,IOUT
WRITE(6,411)TOUT,IUNIT,IOUT
IF(IUNIT .GT. 2 .OR. IUNIT .LT. 1)GO TO 105

C
C   READ HEIGHTS
C   NN=0 FOR INPUT OF ALL HEIGHTS
C   NN=1 FOR CALCULATION OF HEIGHTS
C
READ(5,700)NH,NN
WRITE(6,412)NH,NN
IF(NH .LE. MFL)GO TO 89
IPAR=6
GO TO 110
89 IF(NH .EQ. 1)GO TO 97
READ(5,700)(H(I),I=1,NH)
WRITE(6,413)(H(I),I=1,NH)
GO TO 99
97 READ(5,700)H(1),DH
WRITE(6,414)H(1),DH
DO 98 I=2,NH

```

SUBROUTINE INPUT

```

      IM=I-1
98      H(I)=F(IM)+DH
      C
      C      READ TEMPERATURE PROFILES
      C
99      READ(5,700)NTP
      WRITE(6,415)NTP
      IF(NTP .LE. MTP)GO TO 90
      IPAR=5
      GO TC 110
100     DO 3 IF=1,NTP
      READ(5,700)NNN,(II(J),TT(J),J=1,NNN)
      WRITE(6,416)NNN,(II(J),TT(J),J=1,NNN)
      IF(NAN .GT. 1)GO TC 2
      DO 1 IFF=1,NH
1      T(IP,IFF)=TT(1)
      GO TC 3
2      J=1
      JP1=2
      DO 4 IFF=1,NH
      T(IP,IFF)=TT(J)+(TT(JP1)-TT(J))*(IFF-II(J))/(II(JP1)-II(J))
      IF(IFF .NE. II(JP1))GO TC 4
      IF(JP1 .EQ. NNN)GO TO 4
      J=JP1
      JP1=J+1
4      CONTINUE
3      CONTINUE
      C
      C
      C      READ OUTSIDE PRESSURE PROFILES
      C      NN=0 FOR INPUT OF ALL PRESSURES
      C      NN=1 FOR CALCULATION BY POWER LAW
      C
      READ(5,700)NPO,NN
      WRITE(6,417)NPC,NN
      IF(NFO .LE. MPO)GO TO 91
      IPAR=4
      GO TC 110
91     IF(NN .EQ. 1)GO TO 81
      C
      C      READ ALL OUTSIDE PRESSURES
      C
      DO 6 I=1,NPO
6      READ(5,700) PGZ,(PFO(J,I),J=1,NH)
      WRITE(6,418)PGZ,(PFO(J,I),J=1,NH)
      GO TC 85
      C
      C      CALCULATE OUTSIDE PRESSURES
      C      PATMCS IS ATMOSPHERIC PRESSURE (PA)
      C
81     READ(5,700)VW,HW,XW,(CW(I),I=1,NPO)
      WRITE(6,419)VW,HW,XW,(CW(I),I=1,NPO)
      IF(ILNIT .EQ. 1)VW=VW*0.2778
      IF(ILNIT .EQ. 2)VW=VW*0.4470
      PATMCS=101325.
      TOC=10LT+273.
      IF(IUNIT .EQ. 2)TOC=(TOUT+460.)/1.8
      PVA=176.4*VW*VW/TOC

```

SUBROUTINE INPUT

```

Z=-0.03417/T00
IF(ILNIT .EQ. 2)Z=0.3048*Z
CWM=CW(1)
IF(NFO .EQ. 1)GO TO 212
DO 211 I=1,NP0
IF(CW(I) .LT. CWM)CWM=CW(I)
211 CONTINUE
212 PGZ=FATMCS*EXP(H(NH)*Z)+CWM*PVA*((H(NH)/HW)**(2.*XW))-100.
DO 210 I=1,NH
PH(I)=PATMOS*EXP(H(I)*Z)
210 CONTINUE
DO 82 I=1,NP0
DO 82 J=1,NH
PFO(J,I)=PH(J)+CW(I)*PVA*((H(J)/HW)**(2.*XW))-PGZ
82 CONTINUE
C
C
C BUILDING DATA INPUT
C NFLS = NO. OF FLOORS IN BUILDING
C IF1 = LOWER FLOOR IN SERIES OF SIMILAR FLOORS
C IF2 = UPPER FLOOR IN SERIES OF SIMILAR FLOORS
C NOC = NO. OF COMPARTMENTS PER FLOOR
C NZ = NO. OF CONNECTIONS TO COMPARTMENTS ON SAME FLOOR
C NA = NO. OF CONNECTIONS TO COMPARTMENTS ON FLOOR ABOVE
C
85 I=0
SNCCMP(1)=0.
READ(5,700)NFLS
WRITE(6,420)NFLS
IF(NFLS .GT. NH)GO TO 106
7 READ(5,700)IF1,IF2,NOC
WRITE(6,400)IF1,IF2,NOC
IF(IF1 .GT. IF2)GO TO 107
NCOMF(IF1)=NOC
IFP=IF1+1
SNCCMP(IFP)=SNCCMP(IF1)+NOC
DO 10 IZ=1,NOC
I= I+1
READ(5,700)NZ,NA,NNO,FF(I),IT(I)
WRITE(6,401)NZ,NA,NNO,FF(I),IT(I)
NZZ(I)=NZ
NN=NZ+NA
IFLOOR(I)=IF1
IF(NN .LE. MC)GO TO 111
IPAR=3
GO TO 110
111 IF(NNO .LE. MPO)GO TO 112
IPAR=4
GO TO 110
112 IF(IT(I) .GT. NTP .OR. IT(I) .LT. 1)GO TO 102
NC(I)=NN
IF(NZ .EQ. 0)GO TO 63
C
C INPUT CONNECTIONS TO COMPARTMENTS ON SAME FLOOR
C
READ(5,700)(JC(I,J),C(I,J),AI(I,J),J=1,NZ)
WRITE(6,402)
WRITE(6,403)(JC(I,J),C(I,J),AI(I,J),J=1,NZ)

```

SUBROUTINE INPUT

```

DO 62 J=1,NZ
62 JC(I,J)=JC(I,J)+SNCOMP(IF1)
63 IF(NA .EQ. 0)GO TO 8
C
C      INFUT CONNECTIONS TO COMPARTMENTS ON FLOOR ABOVE
C
NP=NZ+1
READ(5,700)(JC(I,J),C(I,J),AI(I,J),J=NP,NN)
WRITE(6,404)
WRITE(6,403)(JC(I,J),C(I,J),AI(I,J),J=NP,NN)
DO 66 J=NP,NN
66 JC(I,J)=JC(I,J)+NCCMP(IF1)+SNCOMP(IF1)
8 NCC(I)=NNO
IF(NNO .EQ. 0)GO TO 10
C
C      INFUT CONNECTION TO OUTSIDE
C
READ(5,700)(JOC(I,JJ),CO(I,JJ),AO(I,JJ),JJ=1,NNO)
WRITE(6,405)
WRITE(6,403)(JOC(I,JJ),CO(I,JJ),AO(I,JJ),JJ=1,NNO)
DO 9 JJ=1,NNO
9 J=JOC(I,JJ)
PO(I,JJ)=PFO(IF1,J)
10 CONTINUE
IF(IF1 .NE. IF2)GO TO 11
IF(IF1 .EQ. NFLS)GO TO 20
GO TO 19
C
C      ASSIGN DATA FOR FLOORS SIMILAR TO FLOOR IF1
C
11 IFF=IF1+1
DO 17 IFF=IFF,IF2
NCCMP(IFF)=NOC
IFFP=IFF+1
SNCOMP(IFFP)=SNCOMP(IFF)+NOC
DO 16 IZ=1,NOC
16 I=I+1
I1=I2+SNCOMP(IF1)
IFLCCR(I)=IFF
FF(I)=FF(I1)
IT(I)=IT(I1)
NN=NC(I1)
NNO=NCC(I1)
NC(I)=NN
NCC(I)=NNO
IF(IFF .NE. NFLS)GO TO 23
NN=NZZ(I1)
NC(I)=NN
23 IF(NN .EQ. 0)GO TO 14
DO 12 J=1,NN
12 C(I,J)=C(I1,J)
AI(I,J)=AI(I1,J)
JC(I,J)=JC(I1,J)+SNCOMP(IFF)-SNCOMP(IF1)
CONTINUE
14 IF(NNO .EQ. 0)GO TO 16
DO 15 JJ=1,NNO
15 JOC(I,JJ)=JOC(I1,JJ)
J=JOC(I,JJ)

```

SUBROUTINE INPUT

```

      CO(I,JJ)=CO(I1,JJ)
      AO(I,JJ)=AO(I1,JJ)
      FO(I,JJ)=PFO(IFF,J)
15      CONTINUE
16      CONTINUE
17      IF(IF2 .EQ. NFLS) GO TO 20
18      CONTINUE
19      GO TC 7
20      N=I
      N2=N
      IF(N .LE. MB) GO TO 114
      IPAR=7
      GO TC 110
C
C      SHAFT DATA INPUT
C
114      READ(5,700)NS
      IF(NS .LE. MS) GO TC 113
      IPAR=2
      GO TC 110
113      DO 100 IS=1,NS
      READ(5,603)(TITSH(IS,I),I=1,5)
      WRITE(6,406)(TITSH(IS,I),I=1,5)
      READ(5,700)CS(IS),NFS1(IS),NFS2(IS),ITS(IS)
      WRITE(6,407)CS(IS),NFS1(IS),NFS2(IS),ITS(IS)
      N1=N2+1
      N2=N1+NFS2(IS)-NFS1(IS)
      NS1(IS)=N1
      NS2(IS)=N2
      IFF=NFS1(IS)-1
      READ(5,700)NNO,FFF,JCP,CC,AA
      WRITE(6,408)NNO,FFF,JCP,CC,AA
      IF(NNO .EQ. 0) GO TO 21
      READ(5,700)(JOC(N1,J),CO(N1,J),AO(N1,J),J=1,NNO)
      WRITE(6,403)(JOC(N1,J),CO(N1,J),AO(N1,J),J=1,NNO)
21      DO 24 I=N1,N2
      NC(I)=1
      NCO(I)=NNO
      IFF=IFF+1
      IFLOC(I)=IFF
      IF(IF2 .GT. NFLS) GO TO 25
      FF(I)=FFF
      IF(JCP .GT. NCOMP(IFF)) GO TO 25
      JC(I,1)=JCP+SNCOMP(IFF)
      C(I,1)=CC
      AI(I,1)=AA
26      IF(NNO .EQ. 0) GO TC 24
      DO 22 J=1,NNO
      JJ=JOC(N1,J)
      FO(I,J)=PFO(IFF,JJ)
      JOC(I,J)=JJ
      CO(I,J)=CO(N1,J)
22      AO(I,J)=AO(N1,J)
      GO TC 24
25      NC(I)=0
      GO TC 26
24      CONTINUE
C

```

SUBROUTINE INPUT

```

C      EXCEPTIONS TO GENERAL SHAFT INPUT
C      NNN = NO. OF EXCEPTIONS
C      KE = 1 FOR FF EXCEPTION
C      KE = 2 FOR OUTSIDE CONNECTION
C      KE = 3 FOR INTERNAL CONNECTION
C
      READ(5,700)NNN
      IF(NNN .EQ. 0)GO TO 100
      DO 69 IK=1,NNN
      READ(5,700)KE, IFF
      WRITE(6,409)KE, IFF
      I=NS1(IS)+IFF-NFS1(IS)
      IF(KE .EQ. 1)GO TO 41
      IF(KE .EQ. 2)GO TO 42
      IF(KE .EQ. 3)GO TO 51
      GO TO 104
41      READ(5,700)FF(I)
      WRITE(6,410)FF(I)
      GO TO 69
42      READ(5,700)J,CCO,AAO
      WRITE(6,405)
      WRITE(6,403)J,CCO,AAO
      NNC=NCO(I)
      IF(NNC .EQ. 0)GO TO 44
      DO 43 K=1,NNC
      IF(JCC(I,K) .EQ. J)GO TO 46
43      CONTINUE
44      NJC=NNC+1
      NCO(I)=NJC
47      PO(I,NJO)=PFO( IFF, J)
      JOC(I,NJO)=J
      CO(I,NJO)=CCO
      AO(I,NJO)=AAO
      GO TO 69
46      NJO =K
      KK=K+1
      IF(CCO .NE. 0)GO TO 47
      NJC=NNC-1
      NCO(I)=NJO
      IF(NJO .EQ. 0)GO TO 69
      DO 45 K=KK,NNC
      KM=K-1
      FO(I,KM)=PO(I,K)
      JOC(I,KM)=JOC(I,K)
      CO(I,KM)=CO(I,K)
49      AO(I,KM)=AO(I,K)
      GO TO 69
51      READ(5,700)JCP,CC,AA
      WRITE(6,402)
      WRITE(6,403)JCP,CC,AA
      J=JCF+SNCOMP( IFF)
      NN=NC(I)
      IF(NN .EQ. 0)GO TO 53
      DO 52 K=1,NN
      IF(JC(I,K) .EQ. J)GO TO 55
52      CONTINUE
      IF(CC .NE. 0.)GO TO 53
      WRITE(6,520)IS,KE, IFF

```

SUBROUTINE INPUT

```

      GO TC 69
53    NJ=NN+1
      NC(I)=NJ
54    JC(I,NJ)=J
      C(I,NJ)=CC
      AI(I,NJ)=AA
      GO TC 69
55    NJ=K
      KK=K+1
      IF(AA .NE. 0.) GO TO 54
      NJ=NN-1
      NC(I)=NJ
      IF(NJ .EQ. 0) GO TO 69
      DO 61 K=KK,NN
      KM=K-1
      JC(I,KM)=JC(I,K)
      C(I,KM)=C(I,K)
61    AI(I,KM)=AI(I,K)
69    CONTINUE
100   CONTINUE
      NT=N2
      IF(NT .LE. MM) GO TO 160
      IPAR=1
      GO TC 110
C
C     PRINT OUTSIDE TEMPERATURE
C
160   WRITE(6,601)(TITLE(I),I=1,12)
      IF(ILNIT .EQ. 1)WRITE(6,800)TOUT
      IF(ILNIT .EQ. 2)WRITE(6,500)TOUT
      IF(ILNIT .EQ. 2)TOUT=(TOUT-32.)/1.8
      TOUT=TCUT+273.
C
C     PRINT HEIGHT AND TEMPERATURE PROFILES
C
      IF(ILNIT .EQ. 1)WRITE(6,811)(IP,IP=1,NTP)
      IF(ILNIT .EQ. 2)WRITE(6,511)(IP,IP=1,NTP)
      WRITE(6,813)
      DO 30 IFF=1,NH
      WRITE(6,812)H(IFF),(T(IP,IFF),IP=1,NTP)
30    C
C     CONVERT TEMPERATURES TO DEG K
C
      DO 33 IFF=1,NH
      DO 33 IP=1,NTP
      IF(ILNIT .EQ. 2)T(IP,IFF)=(T(IP,IFF)-32.)/1.8
33    T(IP,IFF)=T(IP,IFF)+273.
C
C     PRINT OUTSIDE PRESSURE PROFILES
C
      IF(ILNIT .EQ. 1)GO TO 79
      WRITE(6,514)(IP,IP=1,NPC)
      WRITE(6,813)
      DO 76 IFF=1,NH
      DO 77 J=1,NPO
77    PFO(IFF,J)=PFO(IFF,J)/248.8
      WRITE(6,515)H(IFF),(PFO(IFF,J),J=1,NPO)
      DO 76 J=1,NPO

```

SUBROUTINE INPUT

```

78   PFC( IFF,J)=PFO( IFF,J)*24E.8
76   CONTINUE
    GO TO 83
79   WRITE(6,814)( IP,IP=1,NPO)
    WRITE(6,813)
    DO 31 IFF=1,NH
    WRITE(6,815)H( IFF),(PFO( IFF,J),J=1,NPO)
31   CONTINUE
C
C       CORRECT FOR CONNECTIONS ONLY INPUTED ONCE
C
83   DO 60 I=1,NT
    NN=NC(I)
    IF(NN .EQ. 0)GO TO 60
    DO 58 JJ=1,NN
    J=JC(I,JJ)
    IF(J .EQ. 0)GO TO 58
    NNJ=NC(J)
    IF(NNJ .EQ. 0)GO TO 57
    DO 56 IA=1,NNJ
    IF(JC(J,IA) .EQ. 1)GO TO 58
56   CONTINUE
57   NNJ=NNJ+1
    IF(NNJ .LE. MC)GO TO 59
    IPAR=3
    GO TO 110
59   NC(J)=NNJ
    JC(J,NNJ)=I
    C(J,NNJ)=C(I,JJ)
    AI(J,NNJ)=AI(I,JJ)
    IF(J .GT. N .OR. I .GT. N)GO TO 58
    PZ(J,NNJ)=-PZ(I,JJ)
58   CONTINUE
60   CONTINUE
C
C       CORRECT UNITS
C
    IF(IUNIT .EQ. 2)CALL UNITS
C
C       INITIALIZE PZ FOR BUILD COMPARTMENTS
C
87   DO 40 I=1,N
    NN=NC(I)
    IF(NN .EQ. 0)GO TO 40
    IA=I1(I)
    IFI=IFLOOR(I)
    DO 38 JJ=1,NN
    J=JC(I,JJ)
    IFJ=IFLOOR(J)
    IF(IFI .EQ. IFJ)GO TO 38
    IB=I1(J)
    TEMP#=0.5*(T(IA,IFI)+T(IB,IFJ))
    PZ(I,JJ)=3462.*(H( IFJ)-H( IFI))/TEMP#
38   CONTINUE
40   CONTINUE
C
C       INITIALIZE PZ FOR SHAFTS
C

```

SUBROUTINE INPUT

```

DC 5C IS=1,NS
N1=NS1(IS)
N2=NS2(IS)-1
ITT=ITS(IS)
DO 4E I=N1,N2
IFI=IFLOOR(I)
IFJ=IFI+1
TEMPA=0.5*(T(ITT,IFI)+T(ITT,IFJ))
PZ(I,1)=3462.*(H(IFJ)-H(IFI))/TEMPA
45  CONTINUE
50  CONTINUE
C
C    CHECK SHAFT CONNECTIONS
C
DO 240 IS=1,NS
N1=NS1(IS)
N2=NS2(IS)
DO 239 I=N1,N2
NN=NC(I)
IF(NN .EQ. 0)GO TO 239
DO 236 J=1,NN
JJ=JC(I,J)
IF(IFLOOR(I) .NE. IFLOOR(JJ))GO TO 103
236  CONTINUE
239  CONTINUE
240  CONTINUE
RETURN
C
C
C    DIAGNOSTIC OUTPUT
C
102  WRITE(6,902)I,IT(I)
GO TC 109
103  WRITE(6,903)
GO TC 109
104  WRITE(6,904)
GO TC 109
105  WRITE(6,905)
GO TC 109
106  WRITE(6,906)
GO TC 109
107  WRITE(6,907)
GO TC 109
110  WRITE(6,910)PAR(IPAR)
C
C    PRINT CORRECTED BUILDING DATA
C
109  WRITE(6,940)
DO 7C I=1,N
NN=NC(I)
IF(NN .GT. 0)GO TO 180
WRITE(6,941)I,IFLOOR(I),IT(I),FF(I)
GO TC 182
180  WRITE(6,942)I,IFLOOR(I),IT(I),FF(I),JC(I,1),C(I,1),AI(I,1)
IF(NN .EG. 1)GO TO 182
WRITE(6,943)(JC(I,J),C(I,J),AI(I,J),J=2,NN)
182  NNC=NCC(I)
IF(NNO .EQ. 0)GO TC 70

```

SUBROUTINE INPUT

```

WRITE(6,944)(JOC(I,J),CO(I,J),AO(I,J),J=1,NNO)
70 CONTINUE
C
C      PRINT CORRECTED SHAFT INPUT DATA
C
DO 80 IS=1,NS
WRITE(6,816)(TITSH(IS,I),I=1,5)
WRITE(6,806)IS,CS(IS),ITS(IS)
N1=NS1(IS)
N2=NS2(IS)
WRITE(6,807)
CO 75 I=N1,N2
NN=NC(I)
IF(NN .GT. 0)GO TO 72
WRITE(6,801)IFLCOR(I),FF(I)
GO TO 74
72 WRITE(6,808)IFLCOR(I),FF(I),JC(I,1),C(I,1),AI(I,1)
IF(NN .EQ. 1)GO TO 74
WRITE(6,809)(JC(I,J),C(I,J),AI(I,J),J=2,NN)
74 NNC=NC(I)
IF(NNO .EQ. 0)GO TO 75
WRITE(6,810)(JOC(I,J),CO(I,J),AO(I,J),J=1,NNO)
75 CONTINUE
80 CONTINUE
STOP
C
C      FORMAT STATEMENTS
C
400 FORMAT(5X,5HIF1 =,I3,7H, IF2 =,I3,7H, NDC =,I3)
401 FORMAT(5X,4HNZ =,I3,6H NA =,I3,7H, NNO =,I3,6H, FF =,F8.1,
+ 7H, IT =,I3)
402 FORMAT(5X,25HCONNECTION ON SAME FLOOR )
403 FORMAT(5X,3HJ =,I3,5H, C =,F10.3,5H, A =,F9.4)
404 FORMAT(5X,26HCONNECTION TO FLOOR ABOVE )
405 FORMAT(5X,22HCONNECTION TO OUTSIDE )
406 FORMAT(5X,5A4)
407 FORMAT(5X,4HCS =,F9.1,8H, NFS1 =,I3,8H, NFS2 =,I3,7H, ITS =,I3)
408 FORMAT(5X,5HNNO =,I3,7H, FFF =,F8.1,5H, J =,I3,5H, C =, F10.3,
+ 5H, A =,F9.4)
409 FORMAT(5X,4HKE =,I3, 7H, IFF =,I3)
410 FORMAT(5X,4HFF =,F8.1)
411 FORMAT(5X,6HTOUT =,F6.0,5H, IUNIT =,I3,8H, IOUT =,I3)
412 FORMAT(5X,4HNN =,I3,6H, NN =,I3)
413 FORMAT(5X,7HHEIGHTS /(10F8.2))
414 FORMAT(5X,6HH(1) =,F8.2,6H, DH =,F8.2)
415 FORMAT(6X,5HNTF =,I3)
416 FORMAT(5X,20HTEMPERATURE PROFILE /15,(10(I4,F7.1)))
417 FORMAT(5X,5HNPO =,I3,6H, NN =,I3)
418 FORMAT(5X,5HPGZ =,F12.1/17HPRESSURE PROFILE /(10F12.1))
419 FORMAT(5X,4HVV =,F6.1,6H, HW =,F6.1,6H, XW =,F4.2,6H, CW =,
+ (10F4.2))
420 FORMAT(/5X,6HNFLS =,I3)
500 FORMAT(/10X,20HOUTSIDE TEMPERATURE ,F6.1,2H F)
511 FORMAT( ///5X,6HHEIGHT,5X,29HTEMPERATURE PROFILES (DEG F) /
+ 7X,2HFT,3X,19I6)
514 FORMAT(///5X,6HHEIGHT ,5X,26HOUTSIDE PRESSURE PROFILES
1 11F (IN H2O) /7X,2HFT,3X,8I10)
515 FORMAT(F11.2,3X,8F10.3)

```

SUBROUTINE INPUT

```

E20  FORMAT(///5X,15FERROR IN SHAFT ,I2,15HEXCEPTION KE = ,I2,
+ 2X,5HFLOOR ,I3//)
E00  FORMAT(18A4)
E01  FORMAT(1F1///10X,18A4///)
E03  FORMAT(5A4)
700  FORMAT( )
E00  FORMAT(//10X,20HOUTSIDE TEMPERATURE ,F6.1,2H C)
E01  FORMAT(I13,F11.1)
E06  FORMAT( 10X,12HSHAFT NUMBER ,I4/10X,17HSHAFT COEFFICIENT ,F10.1/
1 10X,20HTEMPERATURE PROFILE ,I4)
807  FORMAT(/21X,5HFIXED,25X,4HFLOW,12X,4HFLOW/10X,5HFLOOR,6X,
1 4FFLOW,5X,12HCONNECTED TO ,6X,11HCOEFFICIENT ,6X,8H AREA
2 /)
808  FORMAT(I13,F11.1,6X,5HPOINT,I5,F16.1,F15.4)
E09  FORMAT(30X,5HPOINT,I5,F16.1,F15.4)
E10  FORMAT(30X,7HOUTSIDE ,I3,F16.1,F15.4)
E11  FORMAT( ///5X,6FHEIGHT,5X,29HTEMPERATURE PROFILES (DEG C) /
+ 7X,2HM ,3X,19I6)
E12  FORMAT(F11.2,3X,19F6.1)
E13  FORMAT(/)
E14  FORMAT(///5X,6HHEIGHT ,5X,26HOUTSIDE PRESSURE PROFILES
1 11F (FASCALS) /7X,2HM ,3X,8I10)
E15  FORMAT(F11.2,3X,8F10.1)
E16  FORMAT(///10X,5A4)
E17  FORMAT(10X,45HFLOW COEFFICIENTS CORRECTED FOR TEMPREATURE )
S02  FORMAT(10(/),10X,11HCCMPARTMENT ,I4/
1 10X,20HTEMPERATURE PROFILE ,I4,17H DOES NOT EXIST /
+ 10X,16HPROGRAM STOPPED ,10(/))
S03  FORMAT(10(/),5X,23HSHAFT CONNECTION ERROR ,
1 /10X,16HPROGRAM STOPPED ,10(/))
S04  FORMAT(10(/),10X,40HINPUT ERROR IN EXCEPTIONS TO SHAFT DATA
1 /10X,16HPROGRAM STOPPED ,10(/))
S05  FORMAT(10(/),10X,37HINPUT ERROR IN UNIT TYPE DESIGNATION /
1 10X,16HPROGRAM STOPPED ,10(/))
S06  FORMAT(10(/),10X,37HINPUT ERROR NO. OF FLOORS EXCEEDS NH /
1 10X,16HPROGRAM STOPPED ,10(/))
S07  FORMAT(10(/),10X,25HINPUT ERROR IF1 .GT. IF2 /
1 10X,16HPROGRAM STOPPED ,10(/))
S10  FORMAT(10(/),10X,36HINPUT EXCEEDS DIMENSION PARAMETER ,A3/
+ 10X,16HPROGRAM STOPPED ,10(/))
S30  FORMAT(10X,3A6)
S35  FORMAT(// 10X,26HFLOW COEFFICIENTS AS READ )
S40  FORMAT(10X,15HBUILDING DATA //34X,11HTEMPERATURE ,4X,5HFIXED,
1 12X,2(11X,4HFLOW)/10X,11HCOMPARTMENT ,4X,5HFLOOR,6X,7HPROFILE,
2 6X,4FFLOW,5X,12HCCONNECTION TO ,4X,11HCOEFFICIENT ,4X,
3 8F AREA )
S41  FORMAT(/4X,3I12,F14.1)
S42  FORMAT(/4X,3I12,F14.1,4X,5HPOINT,I7,F11.2,F15.4)
S43  FORMAT(58X,5HPCINT,I7,F11.2,F15.4)
S44  FORMAT(58X,9HOUTSIDE ,I3,F11.2,F15.4)
END

```

ENDG,P

SUEROUTINE CORR.L,1

SUBROUTINE CORR

INBS*PLIES.S+CW A.CORR
SUBROUTINE CORR

```

C
C      THIS ROUTINE CALCULATES ADJUSTED FLOW COEFFICIENTS
C      (C1,C2,CO1,CO2)
C
PARAMETER (MM=140,MS=8,MC=9,MFO=2,MTP=2,MFL=25,MB=50)
COMMON /CORR/C1(MM,MC),C2(MM,MC),CO1(MM,MPO),CO2(MM,MPO)
COMMON NT, P(MM),C(MM,MC),NC(MM),JC(MM,MC),ITS(MS),
1 FC(MM,MC),PZ(MM,MC),PO(MM,MPO),CO(MM,MPO),F(MM),PFO(MFL,MPO),
2 FF(MM),FO(MM,MFO),CS(MS),PS(MFL),NS1(MS),NS2(MS),
3 FSS(MS),N,NS,NPO,ICONV,E,IBUG,AI(MM,MC),AO(MM,MPO),TITSH(MS,5),
4 NF,F(MFL),IFLOOR(MM),T(MTP,MFL),NFS1(MS),NFS2(MS),IT(MB),NTP
5 ,NCC(MM),JOC(MM,MFO),TOUT
DOUELE PRECISION P,PO,PS
DO 12 I=1,NT
C
C      CORRECT C
C
PATMCS=101325.
EB=1000.*SQRT(2.*PATMOS/287.)/1.2
NN=NC(I)
IF(I .GT. N)GO TO 1
IP=IT(I)
GO TO 4
1 DO 2 IS=1,NS
IF(I .LE. NS2(IS) .AND. I .GE. NS1(IS))GO TO 3
2 CONTINUE
WRITE(6,700)
STOP
3 IP=ITS(IS)
4 IFF=IFLOOR(I)
T1=T(IP,IFF)
IF(NN .EQ. 0)GO TO 10
DO 9 J=1,NN
JJ=J(I,J)
C1(I,J)=BB*C(I,J)*AI(I,J)/SQRT(T1)
IF(JJ .GT. N)GO TO 5
IP=IT(JJ)
GO TO 8
5 DO 6 IS=1,NS
IF(JJ .LE. NS2(IS) .AND. JJ .GE. NS1(IS))GO TO 7
6 CONTINUE
WRITE(6,700)
STOP
7 IP=ITS(IS)
8 IFF=IFLOOR(JJ)
T2=T(IP,IFF)
C2(I,J)=BB*C(I,J)*AI(I,J)/SQRT(T2)
9 CONTINUE
C
C      CORRECT CO
C
10 NNC=NC(I)
IF(NNC .EQ. 0)GO TO 12
DO 11 J=1,NNC
CO1(I,J)=BB*CO(I,J)*AO(I,J)/SQRT(T1)

```

SUBROUTINE CORR

```
      CO2(I,J)=BB*CO(I,J)*AC(I,J)/SQRT(TOUT)
11     CONTINUE
12     CONTINUE
      RETURN
700    FORMAT(///10X,36HPROGRAM STOPPED IN SUBROUTINE CORR  //)
      END
```

@FDG,P

SUBROUTINE INIT.L,1

SUBROUTINE INIT

```

&NBS*PLIES$.SCHW A.INIT
  SUBROUTINE INIT

```

```

C
C
C
C

```

THIS ROUTINE INITIALIZES THE PRESSURE ARRAY

```

PARAMETER (MM=140,MS=8,MC=9,MFO=2,MTP=2,MFL=25,MB=50)
PARAMETER (MBP=MB+1)
COMMON /CORR/C1(MM,MC),C2(MM,MC),CO1(MM,MPO),CO2(MM,MPO)
COMMON NT, P(MM),C(MM,MC),NC(MM),JC(MM,MC),ITS(MS),
1 FC(MM,MC),PZ(MM,MC),PC(MM,MPC),CO(MM,MPO),F(MM),PFO(MFL,MPO),
2 FF(MM),FO(MM,MPO),CS(MS),PS(MFL),NS1(MS),NS2(MS),
3 FSS(MS),N,NS,NPO,ICCNV,E,IEUG,AI(MM,MC),AO(MM,MPO),TITSH(MS,5),
4 NH,F(MFL),IFLOOR(MM),T(MTP,MFL),NFS1(MS),NFS2(MS),IT(MB),NTP
5 ,NCC(MM),JGC(MM,MFC),TOUT
DOUBLE PRECISION F,FO,FS
DIMENSION SC(MS),SCO(MS)
COMMON /MAT/A(ME,MEP),XX(MB),NNN
DOUBLE PRECISION A,XX
NNN=N

```

```

C
C
C

```

CALCULATE AVERAGE OUTSIDE PRESSURE

```

SUM=C.
DO 10 J=1,NPO
DO 10 I=1,NH
10 SUM=SUM+PFO(I,J)
PA=SUM/(NPO*NH)

```

```

C
C
C
C
C
C

```

THE DO LOOP TO STATEMENT 30 ESTIMATES
SHAFT PRESSURES

```
DO 30 IS=1,NS
```

```

C
C
C

```

CALCULATE SHAFT PRESSURE DIFFERENCE , DP

```

SUM=C.
SUMN=0.
N1=NS1(IS)
N2=NS2(IS)
DO 18 I=N1,N2
SUM=SUM+FF(I)
NN=NC(I)
IF(NN .EQ. 0.)GO TO 16
DO 15 J=1,NN
SUMN=SUMN+C1(I,J)
15 CONTINUE
SC(IS)=SUMN
16 NNC=NCC(I)
IF(NNO .EQ. 0)GO TO 18
DO 17 J=1,NNO
SUMN=SUMN+CO1(I,J)
17 CONTINUE
SCO(IS)=SUMN-SC(IS)
18 CONTINUE

```

SUBROUTINE INIT

```

CP2=SUM/SUMN
SIGN=1.
IF(CF2 .LT. 0.)SIGN=-1.
DP=SIGN*(SIGN*DP2)**2
C
C      CALCULATE AVERAGE TEMP OF SHAFT
C
SUM=C.
IP=ITS(IS)
DO 20 I=N1,N2
  IFF=IFLOC(I)
20 SUM=SUM+T(IP, IFF)
  TA=SUM/(N2-N1+1)
C
C      ESTIMATE PRESSURE AT BOTTOM OF SHAFT , PBOT
C
HH=0.5*(H(NH)-H(1))+H(1)
NF1=NF1(IS)
PBOT=PA+DP+3462.*(HH-T(NF1))/TA
C
C      ESTIMATE OTHER SHAFT PRESSURES
C
P(N1)=PBOT
NM=N2-1
DO 24 I=N1,NM
  IP1=I+1
24 P(IP1)=P(I)-PZ(I,1)
30 CONTINUE
C
C      END OF SHAFT PRESSURE ESTIMATES
C
C      SET UP MATRIX FOR BUILDING COMPARTMENTS
C
NP1=N+1
DO 50 I=1,N
  NN=NC(I)
  SUMII=0.
  SUMNF=0.
  IF(NN .EQ. 0.)GO TO 42
  DO 40 JJ=1,NN
    J=JC(I,JJ)
    IF(J .GT. N)GO TO 34
    A(I,J)=C1(I,JJ)
    SUMII=SUMII-C1(I,JJ)
    SUMNF=SUMNF-C1(I,JJ)*PZ(I,JJ)
    GO TO 40
34 SUMII=SUMII-C1(I,JJ)
    SUMNF=SUMNF-C1(I,JJ)*P(J)
40 CONTINUE
42 NNC=NC(I)
  IF(NNC .EQ. 0)GO TO 46
  DO 45 K=1,NNC
    SUMII=SUMII-CO1(I,K)
45 SUMNF=SUMNF-CO1(I,K)*PO(I,K)
46 A(I,1)=SUMII
  A(I,NP1)=SUMNF-FF(I)
50 CONTINUE
C

```

SUBROUTINE INIT

```

C      WRITE MATRIX
C
      IF(IEUG .EQ. 0)GO TO 84
      WRITE(6,802)
      DO 52 I=1,N
      WRITE(6,803)(A(I,J),J=1,NP1)
C
C
C      CALL ROUTINE TO SOLVE FOR INITIAL BUILDING PRESSURES
C
84     CALL SIMEQ
C
C      OUTPUT INITIAL PRESSURES
C
      IF(IEUG .EQ. 0)GO TO 89
      WRITE(6,800)
      WRITE(6,801)(I,XX(I),I=1,N)
      NN=NS1(1)
      WRITE(6,801)(I,P(I),I=NN,NT)
C
C
C      ASSIGN BUILDING PRESSURES
C
89     DO 90 I=1,N
90     P(I)=XX(I)
      RETURN
800    FORMAT(///8(6X,1H1,4X,3HP  ))
801    FORMAT(8(17,F7.1))
802    FORMAT(///10X,20HMATRIX COEFFICIENTS  /)
803    FORMAT(10X,11F11.1)
      END

```

&PDG,P
 SUBROUTINE BLDGP.L,1

SUBROUTINE BLDGP

```

&NBS*PLIES$.SHOW  A.BLDGP
  SUERCUTINE  BLDGP

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C

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THIS ROUTINE CALCULATES STEADY STATE PRESSURES
FOR BUILDING COMPARTMENTS

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  PARAMETER (MM=140,MS=8,MC=9,MPC=2,MTP=2,MFL=25,MB=50)
  COMMON NT, P(MM),C(MM,MC),NC(MM),JC(MM,MC),ITS(MS),
1 FC(MM,MC),PZ(MM,MC),PO(MM,MPO),CO(MM,MPO),F(MM),PFO(MFL,MPO),
2 FF(MM),FO(MM,MPO),CS(MS),PS(MFL),NS1(MS),NS2(MS),
3 FSS(MS),N,NS,NFO,ICONV,E,IBUG,AI(MM,MC),AO(MM,MPO),TITSH(MS,5),
4 NF,F(MFL),IFLOOR(MM),T(MTP,MFL),NFS1(MS),NFS2(MS),IT(MB),NTP
5 ,NCC(MM),JOC(MM,MPC),TOUT
  DOUBLE PRECISION P,PO,PS,PI
  IF(IEUG .GT. 0)WRITE(6,806)
  ITM=100
  ICONV=0
  DO 15 I=1,N

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```

CALCULATE NET FLOW ,FI, INTO POINT I
FI=PFLCW(I,P(I))

CHECK MAGNITUDE OF FI
IF(ABS(FI) .LT. E)GO TO 15
ICCNV=ICCNV+1

```

C
C

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SET LP PARAMETERS FOR ITERATION
DP=1.0
IPHA=1
CPI=C.
EE=0.2*ABS(FI)
IF(EE .LT. E)EE=E
SIGN=1
IF(FI .LT. 0.)SIGN=-1
IK=0
IF(IEUG .GT. 0)WRITE(6,802)

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C
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C

```

ITERATION TO REDUCE MAGNITUDE OF FN
IK=IK+1

```

C
C
C

```

NEW ESTIMATE OF PRESSURE ,PI, AT POINT I
PI=P(I)+SIGN*DP

```

C
C
C

```

CALCULATE NET FLOW ,FN, INTO POINT I USING PI
FN=PFLCW(I,PI)
IF(IEUG.GT.0)WRITE(6,804)I,IK,FI,FN,FP,DPI,DP,OPP,PI,IPHA

```

C
C

```

CHECK MAGNITUDE OF FN
IF(ABS(FN) .LT. EE)GO TO 10

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C
C
C

```

CHECK NUMBER OF ITERATIONS
IF(IK .GT. ITM)GO TO 25

```

C
C

```

CHECK PHASE

SUBROUTINE ELDGP

```

      IF (IPHASE .EQ. 2) GO TO 6
C
C   CHECK FOR TRANSITION FROM PHASE 1 TO PHASE 2
      IF (FI*FN .LT. 0.) GO TO 4
C
C   PHASE 1
      CPI=CP
      CP=5.0*DP
      FI=FN
      GO TO 2
C
C   PHASE 2
4     IPHASE=2
      GO TO 9
6     IF (FI*FN .GT. 0.) GO TO 8
C
C   NEW CP BETWEEN DPI AND DP
8     CPP=CP
      FP=FN
      CP=DFI+((CPP-DPI)*FI/(FI-FN))
      GO TO 2
C
C   NEW CP BETWEEN CP AND CPP
8     FI=FN
      CPI=CP
      CP=DFI+((CPP-DPI)*FN/(FN-FP))
      GO TO 2
10    P(I)=PI
15    CONTINUE
C
      RETURN
25    WRITE(6,800)
      STOP
C
C   FORMAT STATEMENTS
C
800    FORMAT(///10X,20(1H*)///10X,22HEXCESSIVE ITERATIONS /
+ 10X,8FIN BLDGP ///10X,20(1H*)//////)
802    FORMAT(//11X,1HI,2X,2HIT,12X,2HFI,13X,2HFN,13X,2HFP,12X,3HDPI,
+13X,2HCP,12X,3HDPP,13X,2HPFI,3X,5HPHASE /)
804    FORMAT(8X,2I4,3E15.4,4F15.6,15)
806    FORMAT(///10X,6HBLDGP )
      END

```

ENDGP,P

SUBROUTINE SHAFTP.L.1

SUBROUTINE SHAFTP

```

&NBS*PLIB$.SHOW A.SHAFTP
      SUBROUTINE SHAFTP
C
C
C      THIS ROUTINE CALCULATES STEADY STATE PRESSURES
C      FOR SHAFTS
C
C
      PARAMETER (MM=140,MS=8,MC=9,MPG=2,MTP=2,MFL=25,MB=50)
      COMMON NT, F(MM),C(MM,MC),NC(MM),JC(MM,MC),ITS(MS),
1 FC(MM,MC),PZ(MM,MC),PG(MM,MPG),CO(MM,MPO),F(MM),PFO(MFL,MPO),
2 FF(MM),FO(MM,MPO),CS(MS),PS(MFL),NS1(MS),NS2(MS),
3 FSS(MS),N,NS,NPO,ICCNV,E,IBUG,AI(MM,MC),AO(MM,MPO),TITSH(MS,5),
4 NF,T(MFL),IFLCOR(MM),T(MTP,MFL),NFS1(MS),NFS2(MS),IT(MB),NTP
5 ,NCC(MM),JOC(MM,MPO),TOUT
      DOBLE PRECISION P,PG,PS,PI
      IF(IEUG .GT. 0)WRITE(6,806)
      ITM=100
      ICCNV=0
      DO 15 I=1,NS
C
C      CALCULATE NET FLOW ,FI, INTO POINT I
      N1=NS1(I)
      FI=SFLCW(I,P(N1))
C
C      CHECK MAGNITUDE OF FI
      IF(AES(FI) .LT. E)GO TO 15
      ICCNV=ICCNV+1
C
C      SET UP PARAMETERS FOR ITERATION
      DP=1.0
      IPHASE=1
      DPI=C.
      EE=0.2*ABS(FI)
      IF(EE .LT. E)EE=E
      SIGN=1
      IF(FI .LT. 0.)SIGN=-1
      IK=0
      IF(IEUG .GT. 0)WRITE(6,802)
C
C      ITERATION TO REDUCE MAGNITUDE OF FN
      IK=IK+1
C
C      NEW ESTIMATE OF PRESSURE ,PI, AT BOTTOM OF SHAFT I
      PI=P(N1)+SIGN*DP
C
C      CALCULATE NET FLOW ,FN, INTO SHAFT I USING PI
      FN=SFLOW(I,PI)
      IF(IEUG.GT.0)WRITE(6,804)I,IK,FI,FN,FP,DPI,DP,DPP,PI,IPHASE
C
C      CHECK MAGNITUDE OF FN
      IF(AES(FN) .LT. EE)GO TO 10
C
C      CHECK NUMBER OF ITERATIONS
      IF(IK .GT. ITM)GO TO 25
C
C      CHECK PHASE

```

SUBROUTINE SHAFTP

```

      IF(IPHASE .EQ. 2)GO TO 6
C
C   CHECK FOR TRANSITION FROM PHASE 1 TO PHASE 2
      IF(FI*FN .LT. 0.)GO TO 4
C
C   PHASE 1
      CPI=CP
      DP=5.0*DP
      FI=FN
      GO TC 2
C
C   PHASE 2
4      IPHASE=2
      GO TC 5
C
C   IF(FI*FN .GT. 0.)GO TO 8
C
C   NEW CP BETWEEN CPI AND DP
5      CPP=CP
      FP=FN
      DP=DFI+(CPP-DPI)*FI/(FI-FN)
      GO TC 2
C
C   NEW CP BETWEEN DP AND DPP
C
E      FI=FN
      CPI=CP
      DP=DFI+(DPP-DPI)*FN/(FN-FP)
      GO TC 2
10     N2=NS2(I)
      DO 11 IF=N1,N2
      II=IF+1-N1
11     F(IF)=PS(II)
15     CONTINUE
C
      RETURN
25     WRITE(6,800)
      STOP
C
C   FORMAT STATEMENTS
C
800     FORMAT(///10X,20(1H*)///10X,22HEXCESSIVE ITERATIONS /
+ 10X,9FIN SHAFTP ///10X,20(1H*)/////)
E02     FORMAT(//11X,1HI,2X,2HIT,12X,2HFI,13X,2HFN,13X,2HFP,12X,3HDI,
+13X,2HDP,12X,3HDPP,13X,2HFI,3X,5HPPHASE /)
E04     FORMAT(8X,2I4,3E15.4,4F15.6,I5)
E06     FORMAT( ///10X,6HSHAFTP)
      END

```

@FDG,P

SUBROUTINE PZAD .L,1

SUBROUTINE PZAD

```

&NBS*PLIES$.SHOW A.PZAD
      SUBROUTINE PZAD

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C
C      THIS ROUTINE CORRECTS PZ TERMS FOR PRESSURE
C
      PARAMETER (MM=140,MS=8,MC=9,MFO=2,MTP=2,MFL=25,MB=50)
      COMMON NT, P(MM),C(MM,MC),NC(MM),JC(MM,MC),ITS(MS),
1 FC(MM,MC),PZ(MM,MC),PG(MM,MPO),CO(MM,MPO),F(MM),PFO(MFL,MPO),
2 FF(MM),FO(MM,MPO),CS(MS),PS(MFL),NS1(MS),NS2(MS),
3 FSS(MS),N,NS,NFO,ICONV,E,IEUG,AI(MM,MC),AO(MM,MPO),TITSH(MS,5),
4 NH,T(MFL),IFLOOR(MM),T(MTP,MFL),NFS1(MS),NFS2(MS),IT(MB),NTP
5 ,NCC(MM),JOC(MM,MPO),TOUT
      COMMON /PZZ/ PGZ
      DOUBLE PRECISION P,FO,PS
      IF(IEUG .GT. -2)GO TO 1
      WRITE(6,800)
      DO 2 I=1,N
      NN=NC(I)
      IF(NN .EQ. 0)GO TO 2
      WRITE(6,801)(I,J,PZ(I,J),J=1,NN)
2      CONTINUE
      NP1=N+1
      WRITE(6,802)(IL,PZ(IL,1),IL=NP1,NT)
1      DO 10 I=1,N
      NN=NC(I)
      IF(NN .EQ. 0)GO TO 10
      IA=IT(I)
      IFI=IFLOOR(I)
      DO 8 JJ=1,NN
      J=JC(I,JJ)
      IFJ=IFLOOR(J)
      IF(IFI .EQ. IFJ)GO TO 8
      IB=IT(J)
      TEMPA=0.5*(T(IA,IFI)+T(IB,IFJ))
      FAVE=0.5*(P(I)+P(J))+PGZ
      PZ(I,JJ)=(0.03416*PAVE/TEMPA)*(H(IFJ)-H(IFI))
8      CONTINUE
10     CONTINUE
      DO 20 IS=1,NS
      N1=NS1(IS)
      N2=NS2(IS)-1
      ITT=ITS(IS)
      DO 15 I=N1,N2
      IFI=IFLOOR(I)
      IFJ=IFI+1
      TEMPA=0.5*(T(ITT,IFI)+T(ITT,IFJ))
      J=I+1
      PA=0.5*(P(I)+P(J))+PGZ
15     PZ(I,1)=(0.03416*PA/TEMPA)*(H(IFJ)-H(IFI))
20     CONTINUE
      RETURN
800    FORMAT(/10X,10HINITIAL PZ /)
801    FORMAT(10X,3HPZ(,I2,1H,I2,4H) = ,F12.4)
802    FORMAT(10X,3HPZ(,I2,6H,1) ' ,F12.4)
803    FORMAT(/10X,11HADJUSTED PZ /)
      END

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SUBROUTINE OUT

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@NES*PLIES$.SHOW A.OUT
SUBROUTINE OUT

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THIS ROUTINE OUTPUTS FLOWS AND DIFFERENTIAL PRESSURES
FOR ALL SHAFTS AND BUILDING COMPARTMENTS

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PARAMETER (MM=140,MS=8,MC=9,MPC=2,MTP=2,MFL=25,MB=50)
COMMON /CORR/C1(MM,MC),C2(MM,MC),CO1(MM,MPO),CO2(MM,MPO)
COMMON /IO/TITLE(18),IDUT,IUNIT,NCOMP(MFL),SNCOMP(MFL)
COMMON NT, P(MM),C(MM,MC),NC(MM),JC(MM,MC),ITS(MS),
1 FC(MM,MC),PZ(MM,MC),PO(MM,MPO),CO(MM,MPO),F(MM),PFO(MFL,MPO),
2 FF(MM),FO(MM,MPO),CS(MS),FS(MFL),NS1(MS),NS2(MS),
3 FSS(MS),N,NS,NFO,ICONV,E,IBUG,AI(MM,MC),AO(MM,MPO),TITSH(MS,5),
4 NF,F(MFL),IFLOOR(MM),T(MTP,MFL),NFS1(MS),NFS2(MS),IT(MB),NTP
5 ,NCC(MM),JOC(MM,MPC),TOUT
DOUBLE PRECISION P,FO,PS
INTEGER COM

```

```

C
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C
C
C

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```

IUNIT = 1 FOR SI UNITS
IUNIT = 2 FOR ENG UNITS
WHEN IUNIT = 2 GO TO 100
IF(IUNIT .EQ. 2)GO TO 100

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```

BUILDING COMPARTMENT OUTPUT

```

```

1

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```

I=0
IL=0
WRITE(6,800)(TITLE(I),I=1,18)
DO 30 IFF=1,NH
NN=NCOMP(IFF)
IF(NNN .EQ. 0)GO TO 30
DO 25 IC=1,NNN
I=I+1
NN=NC(I)
NCC=NCC(I)
IL=IL+NN+NNO+2
IF(IL .LT. 51)GO TO 2
WRITE(6,800)(TITLE(I),I=1,18)
IL=NN+NNO+2
2 IF(NN .GT. 0)GO TO 3
WRITE(6,801)IFF,IC,P(I),IT(I),FF(I)
GO TO 21
3 DO 20 J=1,NN
JJ=JC(I,J)
DP=F(JJ)-P(I)+PZ(I,J)
CC=C2(I,J)
IF(DP .LT. 0.)CC=C1(I,J)
IF(JJ .LE. N)GO TO 10
DO 5 IS=1,NS
IF(JJ .GE. NS1(IS) .AND. JJ .LE. NS2(IS))GO TO 6
5 CONTINUE
6 IF(J .GT. 1)GO TO 7
WRITE(6,802)IFF,IC,P(I),IT(I),FF(I),(TITSH(IS,K),K=1,5)
+ ,DP,CC,AI(I,1),FC(I,1)
GO TO 20

```

SUBROUTINE OUT

```

7    WRITE(6,803)(TITSH(IS,K),K=1,5),DP,CC,AI(I,J),FC(I,J)
    GO TC 20
10   IFJ=IFLOOR(JJ)
    COM=JJ-SNCOMP(IFJ)
    IF(J .GT. 1)GO TO 12
    WRITE(6,804)IFF,IC,P(I),IT(I),FF(I),IFJ,COM,DP,CC,AI(I,1),FC(I,1)
    GO TC 20
12   WRITE(6,805)IFJ,COM,DP,CC,AI(I,J),FC(I,J)
20   CONTINUE
21   IF(NNO .EQ. 0)GO TO 29
    DO 23 J=1,NNO
    JJ=JCC(I,J)
    CP=PC(I,J)-P(I)
    CC=CC2(I,J)
    IF(DP .LT. 0.)CC=CO1(I,J)
23   WRITE(6,806)JJ,DP,CC,AO(I,J),FO(I,J)
29   WRITE(6,807)F(I)
30   CONTINUE
    WRITE(6,900)

C
C    STAFF OUTPUT
C
    DO 6C IS=1,NS
    N1=NS1(IS)
    N2=NS2(IS)
32   WRITE(6,814)(TITLE(I),I=1,18)
    WRITE(6,808)(TITSH(IS,K),K=1,5),ITS(IS),CS(IS)
    DO 5C I=N1,N2
    NN=NC(I)
    IF(NN .GT. 0)GO TO 35
    WRITE(6,809)IFLOOR(I),P(I),FF(I)
    GO TC 41
35   DO 4C J=1,NN
    JJ=JC(I,J)
    CP=P(JJ)-P(I)
    CC=C2(I,J)
    IF(DP .LT. 0.)CC=C1(I,J)
    IFJ=IFLOOR(JJ)
    COM=JJ-SNCOMP(IFJ)
    IF(J .GT. 1)GO TO 36
    WRITE(6,810)IFLOOR(I),P(I),FF(I),IFJ,COM,DP,CC,AI(I,1),FC(I,1)
    GO TC 40
36   WRITE(6,811)IFJ,CCM,DP,CC,AI(I,J),FC(I,J)
40   CONTINUE
41   NNC=NCC(I)
    IF(NNO .EQ. 0)GO TO 50
    DO 46 J=1,NNO
    JJ=JCC(I,J)
    CP=PC(I,J)-P(I)
    CC=CC2(I,J)
    IF(CP .LT. 0.)CC=CO1(I,J)
46   WRITE(6,812)JJ,DP,CC,AO(I,J),FO(I,J)
50   CONTINUE
    WRITE(6,813)FSS(IS)
    WRITE(6,900)
60   CONTINUE
    GO TC 165
C

```

SUBROUTINE OUT

```

C      BUILDING DATA OUTPUT FOR IUNIT = 2
C
100    I=0
      IL=0
      WRITE(6,800)(TITLE(I),I=1,18)
      CO 130 IFF=1,NH
      NNN=NCCMF(IFF)
      IF(NNN .EQ. 0)GO TO 130
      CO 129 IC=1,NNN
      I=I+1
      FFI=F(I)/0.4719
      PIII=P(I)/248.8
      FFF=FF(I)/0.4719
      NN=NC(I)
      NNC=NCC(I)
      IL=IL+NN+NNC+2
      IF(IL .LT. 51)GO TO 102
      WRITE(6,800)(TITLE(I),I=1,18)
      IL=IL+NN+NNC+2
102    IF(NN .GT. 0)GO TO 103
      WRITE(6,601)IFF,IC,PIII,IT(I),FFF
      GO TO 121
103    CO 120 J=1,NN
      FCCC=FC(I,J)/0.4719
      JJ=JC(I,J)
      CP=(F(JJ)-P(I)+PZ(I,J))/248.8
      AAI=AI(I,J)/0.0929
      CC=C2(I,J)
      IF(DF .LT. 0.)CC=C1(I,J)
      CC=CC*33.43
      IF(JJ .LE. N)GO TO 110
      CO 105 IS=1,NS
      IF(JJ .GE. NS1(IS) .AND. JJ .LE. NS2(IS))GO TO 106
105    CONTINUE
106    IF(J .GT. 1)GO TO 107
      WRITE(6,602)IFF,IC,PIII,IT(I),FFF , (TITSH(IS,K),K=1,5)
      + ,CP,CC,AAI,FCCC
      GO TO 120
107    WRITE(6,603)(TITSH(IS,K),K=1,5),DP,CC,AAI,FCCC
      GO TO 120
110    IFJ=1FLOOR(JJ)
      COM=JJ-SNCOMP(IFJ)
      IF(J .GT. 1)GO TO 112
      WRITE(6,604)IFF,IC,PIII,IT(I),FFF ,IFJ,COM,DP,CC,AAI,FCCC
      GO TO 120
112    WRITE(6,605)IFJ,COM,DP,CC,AAI,FCCC
120    CONTINUE
121    IF(NNC .EQ. 0)GO TO 129
      CO 123 J=1,NNC
      FOC=FO(I,J)/0.4719
      JJ=JCC(I,J)
      DP=(FO(I,J)-P(I))/248.8
      AAC=AC(I,J)/0.0929
      CC=CC2(I,J)
      IF(DF .LT. 0.)CC=CC1(I,J)
      CC=CC*33.43
123    WRITE(6,606)JJ,DP,CC,AAC,FOC
129    WRITE(6,807)FFI

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SUBROUTINE OUT

```

130  CONTINUE
    WRITE(6,901)
C
C      SHAFT OUTPUT FOR IUNIT = 2
C
    DO 160 IS=1,NS
      CSS=CS(IS)/0.02992
      FFI=FSS(IS)/0.4719
      N1=NS1(IS)
      N2=NS2(IS)
132  WRITE(6,814)(TITLE(I),I=1,18)
      WRITE(6,808)(TITSH(IS,K),K=1,5),ITS(IS),CSS
      DO 150 I=N1,N2
        FFF=FF(I)/0.4719
        PIII=P(I)/248.8
        NN=NC(I)
        IF(NN .GT. 0)GO TO 135
        WRITE(6,609)IFLOOR(I),PIII,FFF
        GO TC 141
135  DO 140 J=1,NN
        FCCC=FC(I,J)/0.4719
        JJ=JC(I,J)
        DP=(F(JJ)-P(I))/248.8
        AAI=AI(I,J)/0.0929
        CC=C2(I,J)
        IF(CF .LT. 0.)CC=C1(I,J)
        CC=CC*33.43
        IFJ=IFLOOR(JJ)
        COM=JJ-SNCOMP(IFJ)
        IF(J .GT. 1)GO TO 136
        WRITE(6,610)IFLOOR(I),PIII,FFF ,IFJ,COM,DP,CC, AAI,FCCC
        GO TC 140
136  WRITE(6,611)IFJ,COM,DP,CC, AAI,FCCC
140  CONTINUE
141  NNO=NCO(I)
      IF(NNO .EQ. 0)GO TO 150
      DO 146 J=1,NNO
        FOC=FO(I,J)/0.4719
        JJ=JCC(I,J)
        CP=(FO(I,J)-P(I))/248.8
        AAO=AO(I,J)/0.0529
        CC=CC2(I,J)
        IF(CF .LT. 0.)CC=C01(I,J)
        CC=CC*33.43
146  WRITE(6,612)JJ,DP,CC,AAO,FOO
150  CONTINUE
      WRITE(6,813)FFI
      WRITE(6,901)
160  CONTINUE
C
C      SUMMARY OUTPUT
C      USER INSERTS WRITE STATEMENTS TO FILE IOUT
C
165  CONTINUE
      RETURN
C
C      FORMAT STATEMENTS

```

SUBROUTINE OUT

```

C
E01  FORMAT(/4X,I3,I10,F13.3,I8,F12.0)
E02  FORMAT(/4X,I3,I10,F13.3,I8,F12.0,3X,5A4,F14.3,F15.0,F10.3,F11.1)
E03  FORMAT(53X,5A4,F14.3,F15.0,F10.3,F11.1)
E04  FORMAT(/4X,I3,I10,F13.3,I8,F12.0,3X,5HFLOOR,I3,12H COMPARTMENT,I3,
1 F11.3,F15.0,F10.3,F11.1)
E05  FORMAT(53X,5HFLOOR,I3,12H COMPARTMENT, I3,F11.3,F15.0,F10.3,F11.1)
E06  FORMAT(53X,17HOUTSIDE DIRECTION,I3,F14.3,F15.0,F10.3,F11.1)
E09  FORMAT(4X,I3,F10.3,F11.0)
E10  FORMAT(4X,I3,F10.3,F11.0,3X,5HFLOOR,I3,12H COMPARTMENT,I3,F11.3,
1 F15.0,F10.3,F11.1)
E11  FORMAT(31X,5HFLOOR,I3,12H COMPARTMENT,I3,F11.3,F15.0,F10.3,F11.1)
E12  FORMAT(31X,17HOUTSIDE DIRECTION ,I3,F14.3,F15.0,F10.3,F11.1)
E00  FORMAT(1H1,20X,18A4,/94X,8HADJLSTED/35X,4HTEMP,7X,5HFIXED,28X,
1 12HDIFFERENTIAL,5X,4HFLOW,8X,4HFLOW/4X,5HFLOOR,2X,11HCOMPARTMENT
2 ,2X,8HPRESSURE,2X,7HPROFILE,5X,4HFLOW,3X,16HCONNECTION TO ,
3 12X,8HPRESSURE,4X,11HCOEFFICIENT,2X,8H AREA ,5X,4HFLOW /)
E01  FORMAT(/4X,I3,I10,F13.1,I8,F12.0)
E02  FORMAT(/4X,I3,I10,F13.1,I8,F12.0,3X,5A4,F14.1,F15.1,F10.4,F11.1)
E03  FORMAT(53X,5A4,F14.1,F15.1,F10.4,F11.1)
E04  FORMAT(/4X,I3,I10,F13.1,I8,F12.0,3X,5HFLOOR,I3,12H COMPARTMENT,I3,
1 F11.1,F15.1,F10.4,F11.1)
E05  FORMAT(53X,5HFLOOR,I3,12H COMPARTMENT, I3,F11.1,F15.1,F10.4,F11.1)
E06  FORMAT(53X,17HOUTSIDE DIRECTION,I3,F14.1,F15.1,F10.4,F11.1)
E07  FORMAT(115X,F8.1,4H NET)
E08  FORMAT(///20X,5A4//20X,20HTEMPERATURE PROFILE ,I3/ 20X,
1 23HSHAFT FLOW COEFFICIENT ,F10.0//72X,8HADJUSTED/24X,5HFIXED,
2 28X,12HDIFFERENTIAL,5X,4HFLOW,8X,4HFLOW/4X,5HFLOOR,2X,8HPRESSURE,
3 5X,4HFLOW,3X,16HCONNECTION TO,12X,8HPRESSURE,4X,11HCOEFFICIENT
4,2X,8H AREA ,5X,4HFLOW /)
E09  FORMAT(4X,I3,F10.1,F11.0)
E10  FORMAT(4X,I3,F10.1,F11.0,3X,5HFLOOR,I3,12H COMPARTMENT,I3,F11.1,
1 F15.1,F10.4,F11.1)
E11  FORMAT(31X,5HFLOOR,I3,12H COMPARTMENT,I3,F11.1,F15.1,F10.4,F11.1)
E12  FORMAT(31X,17HOUTSIDE DIRECTION ,I3,F14.1,F15.1,F10.4,F11.1)
E13  FORMAT(93X,F8.1,4H NET)
E14  FORMAT(1H1,20X,18A4)
S00  FORMAT(//15X,'THE FOLLOWING UNITS ARE USED FOR OUTPUT'
1//5X,'FLOW IN LITERS PER SECCND AT 21 DEG C AND 1 ATM'
2/5X,'PRESSURE IN PASCALS'/5X,'AREA IN METERS SQUARED')
S01  FORMAT(///5X,'THE FOLLOWING UNITS ARE USED FOR OUTPUT'
1 //5X,'FLOW IN CFM AT 70 DEG F AND 1 ATM'
2 /5X,'PRESSURE IN INCHS H2O'/5X,'AREA IN FEET SQUARED')
END

```

ENDG,P

SUEROUTINE UNITS.L,1

SUBROUTINE UNITS

```
@NBS*PLIES$.SHOW A.UNITS
      SUBROUTINE UNITS
```

```

C
C      THIS ROUTINE CONVERTS VARIABLES H,FF,AI,AO,CS TO SI UNITS
C
C
      PARAMETER (MM=140,MS=8,MC=9,MPC=2,MTP=2,MFL=25,MB=50)
      COMMON NT, P(MM),C(MM,MC),NC(MM),JC(MM,MC),ITS(MS),
1 FC(MM,MC),PZ(MM,MC),PD(MM,MPO),CO(MM,MPO),F(MM),PFO(MFL,MPO),
2 FF(MM),FO(MM,MPO),CS(MS),PS(MFL),NS1(MS),NS2(MS),
3 FSS(MS),N,NS,NPO,ICONV,E,IBUG,AI(MM,MC),AO(MM,MPO),TITSH(MS,5),
4 NH,F(MFL),IFLOCR(MM),T(MTP,MFL),NFS1(MS),NFS2(MS),IT(MB),NTP
5 ,NCC(MM),JOC(MM,MPO),TOUT
      DOLELE PRECISION P,PD,PS
      DIMENSION B(5)
      DATA B/0.3048,248.8,0.4719,0.02992,0.0929/
      DO 10 I=1,NH
10      F(I)=H(I)*B(1)
      DO 20 I=1,NT
      FF(I)=FF(I)*B(3)
      DO 16 J=1,MC
      AI(I,J)=AI(I,J)*B(5)
16      CONTINUE
      DO 18 J=1,MPO
      AO(I,J)=AO(I,J)*B(5)
18      CONTINUE
      DO 20 IS=1,NS
20      CS(IS)=CS(IS)*B(4)
      RETURN
      END
```

```
@FDG,P
```

```
SUBROUTINE SIMEQ.L,1
```

SUBROUTINE SIMEQ

```

@NBS*PLIB$.SHOW A.SIMEQ
      SUBROUTINE SIMEQ
C
C      CHOCLESKY'S METHOD OF SOLUTION OF
C      SIMULTANEOUS LINEAR ALGEBRIC EQUATIONS
C
      PARAMETER (MM=140,MS=8,MC=9,MFC=2,MTP=2,MFL=25,MB=50)
      PARAMETER (MBF=MB+1)
      DOUBLE PRECISION A,X
      COMMON /MAT/ A(MB,MBF),X(MB),N
      NP1=N+1
      ZERO=1.0E-35
      K=0
C
C
C      SEE IF A(1,1) IS ZERO
      IF (A(1,1)) .GT. ZERO)GO TO 40
      DO 31 I=1,N
      IF(A(I,1) .NE. 0.)GO TO 32
31 CONTINUE
12 WRITE(6,804)K
      STOP
32 DO 33 J=1,NP1
33 A(1,J)=A(1,J)+A(I,J)
C
C      CALCULATE UPPER AND LOWER
C      TRIANGULAR MATRICES OVER ORIG
C      MATRIX A
40 AA=A(1,1)
      DO 2 J=2,NP1
      A(1,J)=A(1,J)/AA
      DO 10 I=2,N
      K=0
C
C      STORE A(I,1) ... A(I,I) IN X ARRAY
C      IN CASE NEW A(I,1) IS ZERO
C      ROW I CAN BE RECALCULATED
      DO 5 J=1,I
      X(J)=A(I,J)
      K=K+1
      DO 10 J=2,NP1
      IF(J .GT. I)GO TO 8
      JM1=-1
      AA=0.
      DO 3 IR=1,JM1
3 AA=AA+A(I,IR)*A(IR,J)
      A(I,J)=A(I,J)-AA
C
C      CHECK IF A(I,I) IS ZERO
C      IF SO MULTIPLY OLD ROW I BY 2.
C
      IF(I .NE. J)GO TO 10
      IF(A(I,I)) .GT. ZERO)GO TO 10
      DO 6 JJ=1,I
6 A(I,JJ)=X(JJ)
      DO 7 JJ=1,NP1

```

SUBROUTINE SIMEQ

```

7  A(I,J)=2.*A(I,J)
   IF(K .GT. 3)GO TO 12
   GO TO 4
8  IM1=I-1
   AA=0.
   DO 9 IR=1,IM1
9  AA=AA+A(I,IR)*A(IR,J)
   A(I,J)=(A(I,J)-AA)/A(I,I)
10 CONTINUE
C  END OF CALCULATION OF TRIANGULAR MATRICES
C
C
C  EACKWARD SUBSTITUTION
C
   X(N)=A(N,NP1)
   DO 20 II=2,N
   AA=0.
   I=NP1-II
   IP1=I+1
   DO 15 J=IP1,N
15  AA=AA+A(I,J)*X(J)
20  X(I)=A(I,NP1)-AA
C
804  FORMAT(////////10X,16HPROGRAM FAILURE ,I3////////)
      END

```

ENDG,P

FUNCTION FLOW.L,1

FUNCTION FLOW

```

@NBS*PLIES$.SHOW A.FLOW
  FUNCTION FLOW(PI,PJ,PZ,C)
    DOUELE PRECISION PI,PJ
  C
  C    THIS FUNCTION CALCULATES FLOWS BETWEEN TWO POINTS
  C
    IF(C .LT. 0.001)GO TO 10
    DP=PJ-PI+PZ
    SIGN=1.0
    IF(DP .LT. .0)SIGN=-1.
    FLOW=SIGN*C*SQRT(SIGN*DP)
    RETURN
10    FLOW=0.0
    RETURN
  END

```

@HDG,P

FUNCTION PFLOW.L.1

FUNCTION PFLOW

```

&NBS*PLIES$.SHOW A.PFLOW
      FUNCTION PFLOW(I,PI)

```

```

C
C
C
C

```

THIS FUNCTION CALCULATES NET FLOWS INTO POINT I

```

      PARAMETER (MM=140,MS=8,MC=9,MFC=2,MTP=2,MFL=25,MB=50)
      COMMON /CORR/C1(MM,MC),C2(MM,MC),CO1(MM,MPO),CO2(MM,MPO)
      COMMON NT, P(MM),C(MM,MC),NC(MM),JC(MM,MC),ITS(MS),
1 FC(MM,MC),PZ(MM,MC),PC(MM,MPC),CO(MM,MPO),F(MM),PFO(MFL,MPO),
2 FF(MM),FO(MM,MPO),CS(MS),PS(MFL),NS1(MS),NS2(MS),
3 FSS(MS),N,NS,NFO,ICONV,E,IBUG,AI(MM,MC),AO(MM,MPO),TITSH(MS,5),
4 NF,F(MFL),IFLOOR(MM),T(MTP,MFL),NFS1(MS),NFS2(MS),IT(MB),NTP
5 ,ACC(MM),JOC(MM,MPC),TOUT
      DOUBLE PRECISION P,PO,PS,PI
      NN=NC(I)
      SUM=0.
      IF(NN .EQ. 0)GO TO 3
      DO 1 JJ=1,NN
      J=JC(I,JJ)
      CC=C1(I,JJ)
      IF(PI .LT. P(J))CC=C2(I,JJ)
      PZZ=FZ(I,JJ)
      IF(I .GT. N)PZZ=0.
      FC(I,JJ)=FLOW(PI,P(J),PZZ,CC)
1 SUM=SUM+FC(I,JJ)
3 NNC=ACC(I)
      IF(NNO .EQ. 0)GO TO 4
      DO 2 K=1,NNO
      CC=CC1(I,K)
      IF(PI .LT. PO(I,K))CC=CC2(I,K)
      FO(I,K)=FLOW(PI,PO(I,K),0,CC)
2 SUM=SUM+FO(I,K)
4 FFLOW=SUM+FF(I)
      IF(I .LE. N)F(I)=SUM+FF(I)
      RETURN
      END

```

```

&HDG,P

```

FUNCTION SFLOW.L,1

FUNCTION SFLOW

@NBS*PLIE\$.SHOW A.SFLOW

FUNCTION SFLOW(IS,PI)

C
C
C
C
C
C

THIS ROUTINE CALCULATES NET FLOW INTO A SHAFT AND
SHAFT PRESSURE PROFILE

PARAMETER (MM=140,MS=8,MC=9,MPC=2,MTP=2,MFL=25,MB=50)

COMMON NT, P(MM),C(MM,MC),NC(MM),JC(MM,MC),ITS(MS),

1 FC(MM,MC),PZ(MM,MC),PO(MM,MPO),CO(MM,MPO),F(MM),PFO(MFL,MPO),

2 FF(MM),FO(MM,MFO),CS(MS),PS(MFL),NS1(MS),NS2(MS),

3 FSS(MS),N,NS,NPO,ICONV,E,IBUG,AI(MM,MC),AO(MM,MPO),TITSH(MS,5),

4 NF,F(MFL),IFLQOR(MM),T(MTP,MFL),NFS1(MS),NFS2(MS),IT(MB),NTP

5 ,NCC(MM),JOC(MM,MFC),TOUT

DOUBLE PRECISION P,PO,PS,PI

IF(IEUG .GT.1)WRITE(6,800)IS

SUM=C.

N1=NS1(IS)

N2=NS2(IS)

FS(1)=PI

FUP=C.

CSS=CS(IS)

DO 10 I=N1,N2

II=I+1-N1

FLO=FFLOW(I,PS(II))

FUP=FLO+FUP

SUM=SUM+FLO

IF(I .EQ. N2)GO TO 5

IIP1=II+1

SIGN=1

IF(FUP .GT. 0.)SIGN=-1.

PS(IIP1)=PS(II)-PZ(I,1)+SIGN*FUP*FUP/(CSS*CSS)

E IF(IEUG .GT. 1)WRITE(6,801)I,II,PS(II),FLO,FUP,SUM

10

CONTINUE

FSS(IS)=SUM

SFLOW=SUM

RETURN

C
C
C

FORMAT STATEMENTS

E00

FORMAT(///5X,17HFLOW - SHAFT NO ,I5/)

E01

FORMAT(5X,3HI =,I3,5X,4HII =,I3,5X,4HPS =,

+ E15.7,5X,5HFLO =,E10.4,5X,5HFUP =,E10.4,5X,5HSUM =,E10.4/)

END

@ERKPT PRINT\$

FEDERAL INFORMATION PROCESSING STANDARD SOFTWARE SUMMARY

01. Summary date Yr. Mo. Day			02. Summary prepared by (Name and Phone) John Klote 921-3387		03. Summary action New Replacement Deletion ☒ ☐ ☐ Previous Internal Software ID							
04. Software date Yr. Mo. Day			05. Software title A Computer Program for Analysis of Smoke Control Systems		07. Internal Software ID							
06. Short title												
08. Software type ☐ Automated Data System ☒ Computer Program ☐ Subroutine/Module		09. Processing mode ☐ Interactive ☒ Batch ☐ Combination		10. Application area <table style="width: 100%; border: none;"> <tr> <th style="text-align: left; border: none;">General</th> <th style="text-align: left; border: none;">Specific</th> </tr> <tr> <td style="border: none; vertical-align: top;"> ☐ Computer Systems Support/Utility ☒ Scientific/Engineering ☐ Bibliographic/Textual </td> <td style="border: none; vertical-align: top;"> ☐ Management/Business ☐ Process Control ☐ Other </td> </tr> </table>			General	Specific	☐ Computer Systems Support/Utility ☒ Scientific/Engineering ☐ Bibliographic/Textual	☐ Management/Business ☐ Process Control ☐ Other		
General	Specific											
☐ Computer Systems Support/Utility ☒ Scientific/Engineering ☐ Bibliographic/Textual	☐ Management/Business ☐ Process Control ☐ Other											
11. Submitting organization and address Suppression & Extinguishment Group Center for Fire Research National Bureau of Standards Washington, D.C. 20234				12. Technical contact(s) and phone John Klote 921-3387								
13. Narrative Pressurized stairwells and pressurized elevators can be used as a means of providing a smoke free exit route during fire situations. This computer program analyzes systems intended to pressurize stairwells and elevator shafts.												
14. Keywords Air movement; computer programs; egress; elevator shafts; escape means; modeling; pressurization; simulating; smoke control; stairwells												
15. Computer manuf'r and model Univac 1100/82		16. Computer operating system		17. Programing language(s) ANSI FORTRAN		18. Number of source program statements 1756						
19. Computer memory requirements		20. Tape drives		21. Disk/Drum units		22. Terminals						
23. Other operational requirements												
24. Software availability <table style="width: 100%; border: none;"> <tr> <td style="text-align: center;">Available ☒</td> <td style="text-align: center;">Limited ☐</td> <td style="text-align: center;">In-house only ☐</td> </tr> </table>				Available ☒	Limited ☐	In-house only ☐	25. Documentation availability <table style="width: 100%; border: none;"> <tr> <td style="text-align: center;">Available ☐</td> <td style="text-align: center;">Inadequate ☐</td> <td style="text-align: center;">In-house only ☐</td> </tr> </table>			Available ☐	Inadequate ☐	In-house only ☐
Available ☒	Limited ☐	In-house only ☐										
Available ☐	Inadequate ☐	In-house only ☐										
26. FOR SUBMITTING ORGANIZATION USE												

INSTRUCTIONS

01. **Summary Date.** Enter date summary prepared. Use Year, Month, Day format: YYMMDD.
02. **Summary Prepared By.** Enter name and phone number (including area code) of individual who prepared this summary.
03. **Summary Action.** Mark the appropriate box for new summary, replacement summary or deletion of summary. If this software summary is a replacement, enter under "Previous Internal Software ID" the internal software identification as reported in item 07 of the original summary, and enter the new internal software identification in item 07 of this form; complete all other items as for a new summary. If a software summary is to be deleted, enter under "Previous Internal Software ID" the internal software identification as reported in item 07 of the original summary; complete only items 01, 02, 03 and 11 on this form.
04. **Software Date.** Enter date software was completed or last updated. Use Year, Month, Day format: YYMMDD.
05. **Software Title.** Make title as descriptive as possible.
06. **Short Title.** (Optional) Enter commonly used abbreviation or acronym which identifies the software.
07. **Internal Software ID.** Enter a unique identification number or code.
08. **Software Type.** Mark the appropriate box for an Automated Data System (set of computer programs), Computer Program, or Subroutine/Module, whichever best describes the software.
09. **Processing Mode.** Mark the appropriate box for an Interactive, Batch, or Combination mode, whichever best describes the software.
10. **Application Area.**
General: Mark the appropriate box which best describes the general area of application from among:

Computer Systems Support/Utility	Process Control
Management/Business	Bibliographic/Textual
Scientific/Engineering	Other

Specific: Specify the sub-area of application; e.g.: "COBOL optimizer" if the general area is "Computer Systems Support/Utility"; "Payroll" if the general area is "Management/Business"; etc. Elaborate here if the general area is "Other."
11. **Submitting Organization and Address.** Identify the organization responsible for the software as completely as possible, to the Branch or Division level, but including Agency, Department (Bureau/Administration), Service, Corporation, Commission, or Council. Fill in complete mailing address, including mail code, street address, city, state, and ZIP code.
12. **Technical Contact(s) and Phone:** Enter person(s) or office(s) to be contacted for technical information on subject matter and/or operational aspects of software. Include telephone area code. Provide organization name and mailing address, if different from that in item 11.
13. **Narrative.** Describe concisely the problem addressed and methods of solution. Include significant factors such as special operating system modifications, security concerns, relationships to other software, input and output media, virtual memory requirements, and unique hardware features. Cite references, if appropriate.
14. **Keywords.** List significant words or phrases which reflect the functions, applications and features of the software. Separate entries with semicolons.
15. **Computer Manufacturer and Model.** Identify mainframe computer(s) on which software is operational.
16. **Computer Operating System.** Enter name, number, and release under which software is operating. Identify enhancements in the Narrative (item 13).
17. **Programming Language(s).** Identify the language(s) in which the software is written, including version; e.g., ANSI COBOL, FORTRAN V, SIMSCRIPT II.5, SLEUTH II.
18. **Number of Source Program Statements.** Include statements in this software, separate macros, called subroutines, etc.
19. **Computer Memory Requirements.** Enter minimum internal memory necessary to execute software, exclusive of memory required for the operating system. Specify words, bytes, characters, etc., and number of bits per unit. Identify virtual memory requirements in the Narrative (item 13).
20. **Tape Drives.** Identify number needed to operate software. Specify, if critical, manufacturer, model, tracks, recording density, etc.
21. **Disk/Drum Units.** Identify number and size (in same units as "Memory"—item 19) needed to operate software. Specify, if critical, manufacturer, model, etc.
22. **Terminals.** Identify number of terminals required. Specify, if critical, type, speed, character set, screen/line size, etc.
23. **Other Operational Requirements.** Identify peripheral devices, support software, or related equipment not indicated above, e.g., optical character devices, facsimile, computer-output microfilm, graphic plotters.
24. **Software Availability.** Mark the appropriate box which best describes the software availability from among: Available to the Public, Limited Availability (e.g.: for government use only), and For-In-house Use Only. If the software is "Available", include a mail or phone contact point, as well as the price and form in which the software is available, if possible.
25. **Documentation Availability.** Mark the appropriate box which best describes the documentation availability from among: Available to the Public, Inadequate for Distribution, and For In-house Use Only. If documentation is "Available", include a mail or phone contact point, as well as the price and form in which the documentation is available, if possible. If documentation is presently "Inadequate", show the expected availability date.
26. **For Submitting Organization Use.** This area is provided for the use of the organization submitting this summary. It may contain any information deemed useful for internal operation.

U.S. DEPT. OF COMM. BIBLIOGRAPHIC DATA SHEET (See instructions)		1. PUBLICATION OR REPORT NO. NBSIR 82-2512	2. Performing Organ. Report No.	3. Publication Date June 1982
4. TITLE AND SUBTITLE A COMPUTER PROGRAM FOR ANALYSIS OF SMOKE CONTROL SYSTEMS				
5. AUTHOR(S) John H. Klotz				
6. PERFORMING ORGANIZATION (If joint or other than NBS, see instructions) NATIONAL BUREAU OF STANDARDS DEPARTMENT OF COMMERCE WASHINGTON, D.C. 20234			7. Contract/Grant No.	8. Type of Report & Period Covered Final Report
9. SPONSORING ORGANIZATION NAME AND COMPLETE ADDRESS (Street, City, State, ZIP) Department of Health and Human Services Washington, D.C. 20201				
10. SUPPLEMENTARY NOTES ☐ Document describes a computer program; SF-185, FIPS Software Summary, is attached.				
11. ABSTRACT (A 200-word or less factual summary of most significant information. If document includes a significant bibliography or literature survey, mention it here) This paper describes a computer program developed to analyze systems intended to control smoke in building fires. These systems include pressurized stairwells, pressurized elevator shafts, zone smoke control systems, and pressurized corridors. This program calculates air flows and differential pressures throughout a building in which a smoke control system is operating. The basic assumptions and limitations of the program are also discussed. The appendices contain a program listing and examples.				
12. KEY WORDS (Six to twelve entries; alphabetical order; capitalize only proper names; and separate key words by semicolons) Air movement; computer programs; egress; elevator shafts; escape means; modeling; pressurization; simulation; smoke control; stairwells				
13. AVAILABILITY ☒ Unlimited ☐ For Official Distribution. Do Not Release to NTIS ☐ Order From Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402. ☒ Order From National Technical Information Service (NTIS), Springfield, VA. 22161			14. NO. OF PRINTED PAGES 69 15. Price	

